Air Quality Impact Modeling Protocol – Operations and Maintenance Emissions

Outer Continental Shelf Permit

Revolution Wind Farm

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VERSION 2

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Acronyms and Abbreviations

µg/m^3	microgram(s) per cubic-meter
AQRV	Air Quality Related Values
BOEM	Bureau of Ocean Energy Management
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COA	corresponding onshore area
COP	Construction and Operations Plan
CTV(s)	crew transport vessel(s)
g/s	grams per second
GHG(s)	greenhouse gas(es)
H_2SO_4	sulfuric acid
IAC	inter-array cable
ICF	Interconnection Facility
km	kilometer(s)
kW	kilowatt(s)

MAAQS	Massachusetts Ambient Air Quality Standards
MassDEP	Massachusetts Department of Environmental Protection
MERPs	Modeled Emission Rates for Precursors
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NESHAP(s)	National Emission Standards for Hazardous Air Pollutant(s)
NSPS	New Source Performance Standards
nm	nautical miles
NNSR	Nonattainment New Source Review
NO_2	nitrogen dioxide
NOI	Notice of Intent
NO_X	nitrogen oxides
NSR	New Source Review
O_3	ozone
O&M	operations and maintenance
OAQPS	Office of Air Quality and Planning Standards
OCS	outer continental shelf
OCSLA	Outer Continental Shelf Lands Act
OnSS	onshore substation
OSS(s)	offshore substation(s)
OTR	ozone transport region
Pb	lead
PM	particulate matter
$PM_{2.5}$	particulate matter smaller than 2.5 micrometers
PM_{10}	particulate matter smaller than 10 micrometers
PSD	Prevention of Significant Deterioration
PTE	potential to emit
RWEC	Revolution Wind Export Cable
RWF	Revolution Wind Farm
SER(s)	Significant Emission Rate(s)
SFWF	South Fork Wind Farm
SIA(s)	Significant Impact Area(s)
SIL(s)	Significant Impact Level(s)
SO_2	sulfur dioxide
SOV(s)	service operating vessel(s)
tpy	tons per year
U.S.C	United States Code
EPA	United States Environmental Protection Agency
VOC(s)	volatile organic compound(s)
VWF	Vineyard Wind Farm
WEA	Wind Energy Area
WTG(s)	wind turbine generator(s)

1.0 PROJECT DESCRIPTION

Revolution Wind, LLC, a 50/50 joint venture between Orsted North America Inc. and Eversource Investment LLC, proposes to construct and operate the Revolution Wind Farm (RWF) and Revolution Wind Export Cable (RWEC) (herein referred to as the Project). The RWF will be located in federal waters on the outer continental shelf (OCS) in the designated Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A-0486, approximately 15 nautical miles (nm) southeast of Point Judith, Rhode Island, 13 nm east of Block Island, Rhode Island, approximately 7.5 nm south of Nomans Land Island National Wildlife Refuge (uninhabited island), and between approximately 10 to 12.5 nm south/southwest of varying points of Rhode Island and Massachusetts coastlines. The lease area itself is approximately 98 square nm, 13 nm wide and 19 nm long at its furthest points. The RWEC will also be located in federal waters, originating from two proposed offshore substations (OSS) within the lease area, and eventually reaching Rhode Island state waters where the transmission cables will come on shore to be incorporated into the power grid at the proposed onshore substation (OnSS). Immediately neighboring the Project is South Fork Wind Farm (SFWF), which has been issued a final OCS Air Permit (OCS-R1-04), and is also being constructed and operated by the Orsted North America Inc. and Eversource Investment LLC joint venture. Approximately 10 nm away [19 kilometers (km)] is Vineyard Wind Farm (VWF), which has been issued a final OCS Air Permit.

The Project will utilize offshore wind energy to generate up to 880 megawatts (MW) of electric energy for sale. The Project will specifically include the following components:

Offshore:

- up to 100 Wind Turbine Generators (WTGs), each will have a capacity between 8 and 12 MW and connected by a network of Inter-Array Cables (IAC);
- up to two Offshore Substations (OSSs) connected by an OSS-Link Cable; and
- up to two submarine export cables (referred to as the Revolution Wind Export Cable [RWEC]), generally co-located within a single corridor.

Onshore:

- a landfall location located at Quonset Point in North Kingstown, Rhode Island (referred to as the Landfall Work Area);
- up to two underground transmission circuits (referred to as the Onshore Transmission Cable), co-located within a single corridor; and
- a new Onshore Substation (OnSS) and Interconnection Facility (ICF) located adjacent to the existing Davisville Substation with interconnection circuits (overhead and underground) connecting the OnSS and ICF to the existing substation.

In March 2020, the Project submitted a Construction and Operations Plan (COP) to the Bureau of Ocean Energy Management (BOEM), and on April 30, 2021 BOEM published a Notice of Intent to prepare an Environmental Impact Statement. Revolution Wind assumes that all state and federal permits will be issued between Q1 and Q3 2023. Construction will begin as early as Q2 2023, beginning with the installation of the onshore components and initiation of seabed preparation activities (clearing of debris and obstructions).

Figure 1-1 shows the Project lease area, the RWEC route, and the 25-nm radius area in which Project emission sources meeting the OCS source definition are considered OCS sources. A large majority of the Project's operations and maintenance (O&M) emissions will be generated by the propulsion and auxiliary engines of vessels providing support within the lease area and while transiting to and from port(s).

Revolution Wind is considering the use of several existing port facilities located in Rhode Island and New York to support offshore O&M activities.

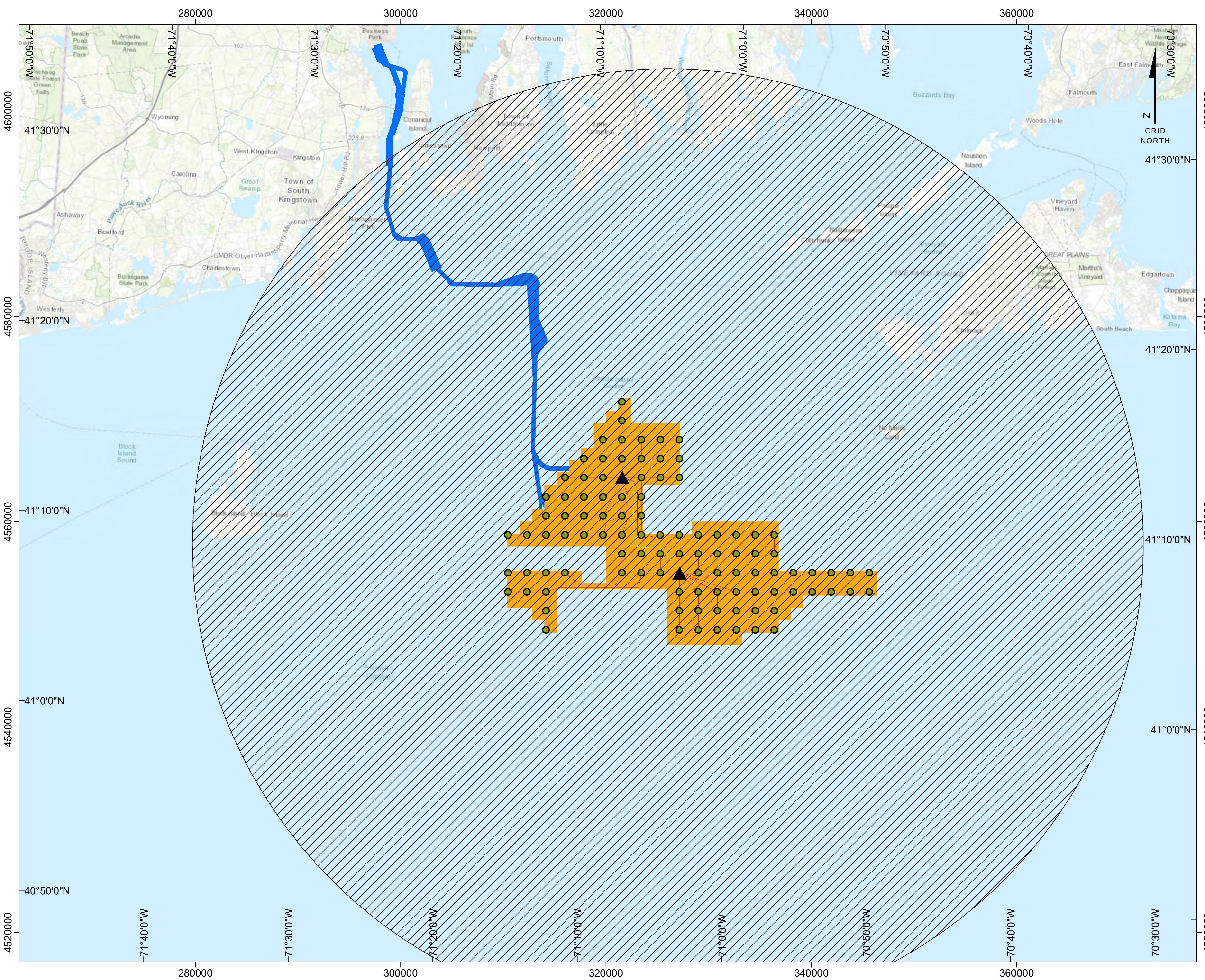
To support the Project's approximate 12-18 month construction period and 20-to-35 years of O&M, aircraft, vessels, vehicles, and non-road fuel-burning equipment will be used, which will generate emissions of criteria and New Source Review (NSR) pollutants. To satisfy the requirements under 40 CFR § § 55, the Project is to obtain from EPA an OCS Air Permit for the Project emissions sources that meet the definition of an OCS source while within 25 nm [46 km] of the Project centroid. This O&M air modeling protocol has been prepared in support of the OCS Air Permit Application for the Revolution Wind Project to fulfill the regulatory requirements codified in Part 55 of Title 40 of the Code of Federal Regulations (40 CFR § 55). A protocol for construction-related emissions and modeling has been prepared separately. Details on construction activity durations and proposed modeling methodology can be found in the separate *Air Quality Impact Modeling Protocol – Construction Emissions*. OCS sources during decommissioning are not regulated by the OCS Air Permit application. A separate OCS Air Permit will likely be sought for decommissioning activities when the Project reaches the end of its life.

The protocol is organized in the following sections: Section 2 provides the air quality regulations and standards applicable to the Project's air quality impact analysis. Section 3 describes the proposed air quality modeling methodology and O&M emission model scenarios. Appendix A includes an evaluation of the performance of the prognostic meteorological data. Appendix B includes figures depicting the O&M source configurations for the modeling and corresponding receptor grids. Appendix C includes EPA's comments on the previous protocol and Revolution Wind's responses to those comments.

Air Quality Impact O&M Modeling Protocol

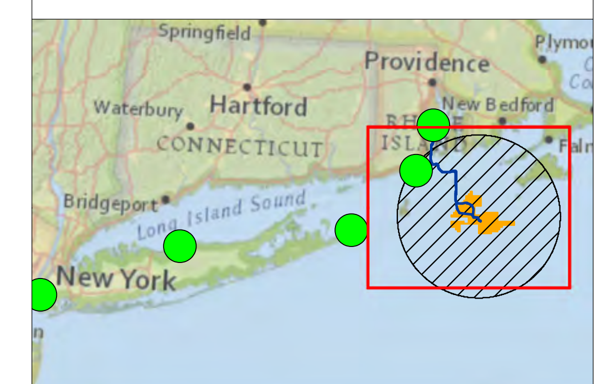
Figure 1-1

OCS Permit Area



Legend

- 25-nm OCS Permit Area
- RWF Lease Area
- RWEC Corridor
- OSSs
- WTGs
- OSS Link
- IAC
- Potential Ports



Reference system: NAD83 (2011)
Projection: UTM Zone 19N

0 2.5 5 7.5 10 Nautical Miles

0 5 10 15 20 Kilometers

Date: 02/02/2022
Document no:

Created by: K. MEARS
Approved by: M. WALLACE

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2.0 APPLICABLE REGULATIONS AND STANDARDS

In accordance with Title III, Section 328 of the Clean Air Act (CAA), in which United States Environmental Protection Agency's (EPA) is required to establish OCS source requirements to attain and maintain Federal and State ambient air quality standards, 40 CFR § 55 establishes the regulatory air requirements for OCS sources located within 25 miles of states' seaward boundaries. Section 328 (a)(4)(c) of the CAA defines an OCS source to include any equipment activity, or facility that emits, or has the potential to emit, any air pollutant; is regulated or authorized under the OCS Lands Act; and is located on the OCS or in or on waters above the OCS. Furthermore, emissions from vessels servicing or associated with an OCS source shall be considered direct emissions from such a source while at the source, and while en route to or from the source when within 25 nm of the source.

OCS sources located within 25 nm of a state's seaward boundary are subject to the federal requirements set forth in 40 CFR § 55.13, and the federal, state, and local requirements of the corresponding onshore area (COA) set forth in 40 CFR § 55.14. Because the Project's lease area is located on the OCS within 25 nm of Massachusetts's seaward boundary, and the Massachusetts has been designated the COA, the Project is subject to the applicable requirements of the most current Massachusetts Air Regulations (310 CMR 6.00 – 8.00) that are incorporated into Appendix A of 40 CFR § 55. Notable federal, state, and local requirements of the COA that pertain to the air modeling protocol include: New Source Performance Standards (NSPS); National Emission Standards for Hazardous Air Pollutants (NESHAPs); New Source Review (NSR) including Prevention of Significant Deterioration (PSD) review, and Nonattainment New Source Review (NNSR); and Massachusetts's Plan Approval Requirements.

2.1 Prevention of Significant Deterioration Review

The PSD program, as set forth in 40 CFR § 52.21 is incorporated by reference into 40 CFR § 55.13(d) of the OCS Air Regulations. PSD applies to OCS sources located within 25 nm of a state's seaward boundary if the PSD requirements are in effect in the COA. Per 40 CFR § 52, Subpart W, the PSD program is in effect in the Project's COA, Massachusetts.

The PSD program applies to new major sources of criteria pollutants or major modifications to existing sources in areas designated as being in attainment with or unclassifiable with the ambient air quality standards. Certain categories of stationary sources listed in 40 CFR 52.21(b)(1)(i)(a) are considered "major" if the source emits or has the potential to emit (PTE) 100 tons per year (tpy) or more of a "NSR regulated pollutant" as defined in 40 CFR § 52.21(b)(50). Per 40 CFR § 52.21(b)(1)(i)(b), all other stationary sources are considered "major" if it emits or has a PTE of 250 tpy or more of a regulated NSR pollutant. Revolution Wind does not fall under any of the stationary source categories listed under 40 CFR § 52.21; therefore, the Project's PSD applicability threshold for a NSR pollutant is 250 tpy.

Typically, when determining PSD applicability, emissions from mobile sources and construction are not included in the potential emissions. However, in the case of OCS sources, Section 328 of the CAA specifies that emissions from vessels servicing or associated with an OCS source shall be considered direct emissions from such a source while at the source, and while enroute to or from the source when within 25 miles of the source and shall be included in the "potential to emit" for an OCS source. Because this definition does not make an exception for vessel and equipment emissions related to construction activity, when determining PSD applicability, the peak year of construction activity typically represents the highest annual emissions and determines whether the Project is subject to PSD review. In the case of Revolution Wind, the Project's potential emissions during construction exceed the 250 tpy PSD threshold and is consequently subject to PSD review.

Once a project is found to be subject to PSD review, the project emissions are then compared to Significant Emission Rates (SERs) to determine to which NSR pollutants the PSD review will apply. In addition, if estimated greenhouse gas (GHG) emissions, expressed as carbon dioxide equivalent (CO_2e), are greater than 75,000 tpy for a project that is a new major stationary source for at least one regulated NSR pollutant that is not GHGs, then GHGs are also included in the PSD review. Table 2-1 presents the Project's maximum potential annual emissions, which is associated with the construction phase. The maximum annual emissions are compared to the PSD major source thresholds to determine to which pollutants the PSD review will apply. Any potential pollutant emissions estimated to be in excess of the SERs will need to be incorporated into the OCS Permit application to demonstrate that emissions from construction or operation of a source will not cause, or contribute to, air pollution in excess of any ambient air quality standards. In the case of this Air Quality Impact Modeling Protocol, the PSD review will apply to carbon monoxide, nitrogen oxides, volatile organic compounds, particulate matter, and GHGs. Although SO_2 is below PSD applicability thresholds, because it is a precursor to $PM_{2.5}$, which is above the PSD threshold, SO_2 will need to be included in the secondary emissions calculations.

Table 2-1 Revolution Wind PSD Review Applicability

New Source Review Pollutant	Potential Annual Emissions (tpy)	SER (tpy)	PSD Review Applies?
Carbon Monoxide	1,155	100	**Yes**
Nitrogen Oxides	4,466	40	**Yes**
Volatile Organic Compounds	92.9	40	**Yes**
Particulate Matter (<10 micrometers)	153	15	**Yes**
Particulate Matter (<2.5 micrometers)	149	10	**Yes**
Sulfur Dioxide	17.0	40	No
Lead	0.0	0.6	No
GHGs (as CO_2e)	336,229	75,000	**Yes**
Sulfuric Acid Mist	1.2	7	No

2.2 Ambient Air Quality Standards

EPA has established two sets of ambient air quality standards, each with their own purpose:

- National Ambient Air Quality Standards (NAAQS), which are the standards that protect public health and welfare and determine whether a given area is classified as an air quality attainment, nonattainment, or maintenance area, and
- PSD increments, which are the standards in place within attainment areas, in addition to the NAAQS, that prevent the air quality from deteriorating to the level set by the NAAQS.

The NAAQS, presented in Table 2-2, consist of primary and secondary standards of various exposure durations. Primary standards are intended to protect human health, whereas secondary standards are intended to protect public welfare from known or anticipated adverse effects from air pollutants, such as damage to property or vegetation. The NAAQS include the following six air contaminants, known as criteria pollutants:

- Carbon monoxide (CO),
- Nitrogen dioxide (NO_2),
- Particulate matter having an aerodynamic diameter of 10 micrometers or less (PM_{10}),
- Particulate matter having an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$),
- Sulfur dioxide (SO_2),
- Ozone (O_3), and
- Lead (Pb).

While the NAAQS are maximum allowable concentrations, PSD increments are the maximum allowable increase in concentration that is acceptable to occur above a baseline concentration for a pollutant. The baseline is defined for each pollutant and, in general, as the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted, known as the minor source baseline date. EPA has established increment standards for NO_2, PM_{10}, $PM_{2.5}$, and SO_2 for various averaging periods. Nomans Land Island in the Town of Chilmark in Dukes County, Massachusetts is the closest land area to the Project Lease Area. In Massachusetts, the PSD Increment, the maximum amount of pollution an area is allowed to increase, is tracked by county for $PM_{2.5}$ and by municipality for NO_2. No previous major source project has triggered the minor source baseline date, the date used to determine the baseline concentration in the area, in Dukes County, or any portion thereof. Because RWF will not be located within the jurisdiction of the Town of Chilmark or Dukes County, the Project does not establish a minor source baseline date for the onshore areas corresponding to the Project. Instead, as described in EPA's Outer Continental Shelf Preconstruction Air Permit Fact Sheet for SFWF, EPA will consider the RWF OCS Lease Area OCS-A 0486 as the baseline area for which the minor source baseline date is set upon receipt of the OCS Permit application (EPA, 2021a). Similarly, the minor source baseline area for SFWF is OCS Lease Area OCS-A 0517, and the minor source baseline date for this area is January 13, 2021. In the case of Revolution Wind, the NO_2, PM_{10} and $PM_{2.5}$ impacts will need to be evaluated within the Air Quality Impact Modeling for comparison against the respective PSD increments.

PSD increments vary in stringency based on the classification of the area. Class I increments are the most stringent and apply to designated Class I areas, such as areas of special national or regional scenic, recreational, or historic value. The nearest Class I areas to the Project are:

- Lye Brook Wilderness area which is 252 km from the project at their nearest points, and
- Brigantine Wilderness area which is 310 km from the Project.

Class II areas comprise the remainder of the United States since there are currently no areas designated as Class III. Therefore, all areas surrounding the Project except for those Class I areas listed above and overwater areas beyond federal waters are all subject to Class II PSD increments. The pollutants and corresponding NAAQS and PSD increment are provided in Table 2-2, along with each standards statistical form.

Table 2-2 Federal Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS (ug/m³)		PSD Increments (ug/m³)	
		Primary	Secondary	Class I	Class II
CO	1-hour	**40,000[1]**	-	-	-
	8-hour	**10,000[1]**	-	-	-
NO_2	1-hour	**188[2]**	-	-	-
	Annual	**100[3]**	**100[3]**	**2.5[8]**	**25[8]**
$PM_{2.5}$	24-hour	**35[4]**	**35[5]**	**2[1]**	**9[1]**
	Annual	**12[5]**	**15[5]**	**1[8]**	**4[8]**
PM_{10}	24-hour	**150[1]**	**150[1]**	**8[1]**	**30[1]**
	Annual	-	-	**4[1]**	**17[1]**
SO_2	1-hour	**196[6]**	-	-	-
	3-hour	-	**1,310[1]**	**25[1]**	**512[1]**
	24-hour	-	-	**5[1]**	**91[1]**
	Annual	-	-	**2[8]**	**20[8]**
Ozone	8-hour	**137.4[7]**	**137.4[7]**	-	-
Lead	Rolling 3-month average	**0.15[8]**	**0.15[8]**	-	-

[1] Not to be exceeded more than once per year
[2] 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[3] Annual mean
[4] 98th percentile, averaged over 3 years
[5] Annual mean, averaged over 3 years
[6] 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[7] Annual fourth-highest daily maximum ozone concentration, averaged over 3 years
[8] Not to be exceeded

Given the extent of modeling effort necessary to demonstrate compliance with these standards, EPA has historically used pollutant-specific concentrations, known as significant impact levels (SILs), to identify the degree of air quality impact that “causes, or contributes to” a violation of a NAAQS or PSD increment. Thus, the SILs are small fractions of the ambient air quality standards above and have been developed separately for NAAQS and PSD increment comparisons. In the case of PSD Increments, Class I and II and III areas each have unique SILs to protect the air quality to the degree necessary for each classification.

Prior to 2010, EPA had expressed support in guidance for applying the values in 40 CFR 51.165(b)(2) as SILs that could be used as part of a demonstration that a source does not cause or contribute to a violation of the NAAQS. However, in 2010 after EPA added Class I, II, and III SILs for $PM_{2.5}$ to 40 CFR 51.166(k)(2) and 52.21(k)(2), it was found that this addition contained rule text that did not provide enough flexibility for permitting authorities to require additional analyses in certain circumstances. As a result of this finding, these sections were vacated and repealed in 2013. However, the $PM_{2.5}$ NAAQS SIL value, that was also incorporated into 40 CFR 51.165(b)(2) because of the 2010 rulemaking, remained, since the accompanying rule text in this section did not have the same limitations, despite the NAAQS SIL values being the same as those for Class II areas in the vacated sections. Therefore, the only SILs that are currently codified are those in 40 CFR 51.165(b)(2), including 1-hour and 8-hour CO; annual NO_2; 24-hour and annual $PM_{2.5}$; 24-hour and annual PM_{10}; and 3-hour, 24-hour and annual SO_2. Although not codified, EPA also issued two memoranda in 2010 that included recommended 1-hour NO_2 and SO_2 SILs (EPA, 2010a, 2010b).

In 2018, rather than promulgating a new rule to address the flaw identified in 40 CFR 51.166(k)(2) and 52.21(k)(2), EPA issued a memorandum that provided recommended 8-hour ozone and 24-hour and annual $PM_{2.5}$ SILs to be applied on a case-by-case basis (EPA, 2018). This approach was intended to provide permitting authorities the opportunity to use their discretion to apply and justify the application of the recommended SILs, while providing EPA with information and feedback to refine the SIL values and specific applications, as necessary, prior to any rulemaking. The memorandum acknowledged that $PM_{2.5}$ SILs still exist within 40 CFR 51.165(b)(2), which limits EPA from recommending NAAQS, Class II, or Class III SILs of a higher value than those currently codified. Therefore, even though EPA derived a SIL value of 1.5 ug/m^3 for 24-hour $PM_{2.5}$, EPA is bound by its previous 24-hour $PM_{2.5}$ SIL value of 1.2 ug/m^3. Conversely, EPA derived a SIL value of 0.2 ug/m^3 for annual $PM_{2.5}$, which is lower than its previous annual $PM_{2.5}$ SIL value of 0.3 ug/m^3. Therefore, the memorandum recommends instead using 0.2 ug/m^3 for the Class II and NAAQS annual $PM_{2.5}$ SIL. Table 2-3 below presents the SILs discussed above.

Table 2-3 Significant Impact Levels

Pollutant	Averaging Period	NAAQS SILs (ug/m^3)	PSD Increment SILs (ug/m^3)	
			Class I	Class II
CO	1-hour	**2,000[1]**	**-**	**-**
	8-hour	**500[1]**	**-**	**-**
NO_2	1-hour	**7.5[2]**	**-**	**-**
	Annual	**1[1]**	**0.1[3]**	**1[3]**
$PM_{2.5}$	24-hour	**1.2[4]**	**0.27[4]**	**1.2[4]**
	Annual	**0.2[4]**	**0.05[4]**	**0.2[4]**
PM_{10}	24-hour	**5[1]**	**0.3[3]**	**5[3]**
	Annual	**1[1]**	**0.2[3]**	**1[3]**
SO_2	1-hour	**7.8[5]**	**-**	**-**
	3-hour	**25[1]**	**1[3]**	**25[3]**
	24-hour	**5[1]**	**0.2[3]**	**5[3]**
	Annual	**1[1]**	**0.1[3]**	**1[3]**
Ozone	8-hour	**1.96[4]**	**-**	**-**

[1] 40 CFR § 51.165(b)(2)
[2] EPA's June 28, 2010, "*General Guidance for Implementing the 1-hour NO_2 National Ambient Air Quality Standard in Prevention of Significant Deterioration Permits, Including an Interim 1-hour NO_2 Significant Impact Level"* Memorandum
[3] 61 FR 38250, "*Prevention of Significant Deterioration (PSD) and Nonattainment New Source Review (NSR)"*
[4] EPA's April 17, 2018, *"Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program"* Memorandum
[5] EPA's August 23, 2010, "*General Guidance for Implementing the 1-hour SO_2 National Ambient Air Quality Standard in Prevention of Significant Deterioration Permits, Including an Interim 1-hour SO_2 Significant Impact Level"* Memorandum

Also within the memorandum, it reads,

> *"Under this program, known as Nonattainment New Source Review (NNSR), sections 173(a)(1) and 173(c) of the Act require increased emissions from a proposed major source or major modification located in a designated nonattainment to be offset by an equal or greater reduction in actual emissions from other sources. 42 U.S.C. § 7503(a)(1)(A), (c). There is no requirement in this part of the Act (like section 165(e) in PSD provisions) to examine air quality in the affected area or the level or degree of air quality Impact from the proposed emissions increase."*

Because the Project is within the ozone transport region (OTR), and the Project NO_X and VOC emissions are expected to be greater than 50 tpy, the Project triggers NNSR for ozone and will need to acquire NO_X offsets as part of the NNSR program. Therefore, the Project will not require modeling of ozone. Table 2-3 below provides the SILs discussed above. Note that there are no Class I PSD Increment SILs for CO, GHGs, or 1-hour NO_2.

2.3 Ambient Air Quality Analysis for Operations and Maintenance Activities

During O&M, emissions from the Project will be considerably lower than emissions during construction. Because the Project triggers PSD review for NO_x, CO, PM_{10} and $PM_{2.5}$; the Project will require an ambient air quality analysis that demonstrates compliance with the SILs, NAAQS, and PSD Increments through dispersion modeling of the O&M phase. In addition, the Project will require an additional impact analysis to determine direct and indirect effects of the Project on industrial growth, soils, vegetation, and visibility around the Project. Each of these analyses are described in the subsections below.

During O&M, OCS sources are only expected for the RWF. No OCS sources are expected to be located along the RWEC. NSR pollutants that are expected to occur during the O&M phase, as discussed in Section 2.1, and are subject to PSD review and dispersion modeling, are provided in Table 2-4 below. Even though SO_2 does not exceed the applicable SER, it has been included in the table for reference in the following section on secondary formation and vegetation impacts.

Table 2-4 O&M OCS Emissions

Applicable OCS Air Permit O&M Emissions (tpy)				
CO	NO_X	SO_2	PM_{10}	$PM_{2.5}$
64.7	207.3	0.8	8.5	8.2

2.3.1 Secondary Impacts

Air contaminants that can lead to secondary formation of $PM_{2.5}$ include SO_2 and NO_X. SO_2 emissions transform into $PM_{2.5}$ through oxidation within the atmosphere, ultimately creating particulate sulfate and ammonium sulfate/bisulfate. NO_X emissions transform into $PM_{2.5}$ through gas-phase reactions to form nitric acid followed by condensation onto atmospheric particles, ultimately creating particulate nitrate.

In EPA's most recent September 20, 2021 guidance, titled *Revised DRAFT Guidance for Ozone and Fine Particulate Matter Permit Modeling*, EPA established new guidance that would require all contributing pollutants to be included in a secondary impact analysis, even if they are below the SER (EPA, 2021b). Therefore, even though the Project's potential SO_2 emissions are below the 40 tpy SER, the SO_2 emissions will be considered for secondary $PM_{2.5}$ impacts. Revolution Wind is proposing the use of the Modeled Emissions Rates for Precursors (MERPs) Tier 1 approach, as provided in the April 30, 2019 EPA guidance (EPA, 2019). As described in the guidance document, to derive a MERP value for the purposes of a PSD compliance demonstration, the model predicted relationship between precursor emissions from hypothetical sources and their modeled downwind impacts can be combined with the appropriate SIL value using the following equation:

$$MERP = appropriate\ SIL\ value * \frac{Modeled\ emission\ rate\ from\ hypothetical\ source}{Modeled\ air\ quality\ impact\ from\ hypothetical\ source}$$

This guidance document describes the approach for determining project specific MERPs as a tool for relating precursor emissions and peak secondary pollutant impacts from hypothetical sources, as modeled by EPA using CAMx. EPA created a total of 105 hypothetical sources across nine climate zones within the contiguous United States. Identifying the source locations by climate zone helps to capture the sensitivity that some climates have to precursor emissions due to higher concentrations of reactive compounds (i.e., PM nitrate impacts would be more sensitive to NO_X in areas rich in ammonia). Each hypothetical source was modeled with two stack heights: 10 meters and 90 meters. The 10-meter stack scenario was modeled with an emission rate of 500 tpy and in some cases 1,000 tpy, while the 90-meter stack scenario was modeled with an emission rate of 500, 1,000, and 3,000 tpy. The resulting impacts are maintained on the

Support Center for Regulatory Atmospheric Modeling's website in two live spreadsheets; one being for evaluating Class I impacts and the other for Class II areas (EPA, 2022). The Class II spreadsheet presents the maximum hypothetical source impacts, at any distance, as MERPs using Class II SILs. Using this spreadsheet, the secondary $PM_{2.5}$ impacts are determined using the following equation:

$$Project\ Impact\ in\ \frac{\mu g}{m^3} = \frac{Emission\ rate\ (tpy)\ from\ project}{MERP\ (tpy)\ from\ hypthetical\ source} * applicable\ Class\ II\ SIL\ value\ (\frac{\mu g}{m^3})$$

The Project will determine the representative daily and annual secondary $PM_{2.5}$ impacts from Project NO_X and SO_2 emissions by following EPA guidance. The most conservative approach is to use the lowest illustrative daily and annual NO_X and SO_2 MERP from the Northeast Climate Zone, 2,218 and 9,647 tpy, and 623 and 4,014 tpy, respectively. With the 207 and 0.8 tpy of Project NO_X and SO_2 O&M emissions presented in Table 2-4, the secondary daily and annual $PM_{2.5}$ impacts using Equation 1, are presented in Table 2-5 below. The predicted secondary $PM_{2.5}$ impacts are below the Class II daily and annual $PM_{2.5}$ SILs (1.2 ug/m^3 and 0.2 ug/m^3). The secondary $PM_{2.5}$ impacts leaves approximately 92% and 99.9% remaining for daily and annual direct $PM_{2.5}$ impacts, respectively. For daily $PM_{2.5}$ impacts, the direct $PM_{2.5}$ impacts will be combined with 0.092 ug/m^3 to and then compared to the daily Class I $PM_{2.5}$ SIL to determine compliance. For annual $PM_{2.5}$ impacts, the direct $PM_{2.5}$ impact will be combined with the 0.0003 ug/m^3 to and then compared to the annual Class I $PM_{2.5}$ SIL to determine compliance.

Table 2-5 First-Level Secondary $PM_{2.5}$ Impacts

Daily $PM_{2.5}$					Annual $PM_{2.5}$				
NO_X MERP (tpy)	NO_X Impact (ug/m^3)	SO_2 MERP (tpy)	SO_2 Impact (ug/m^3)	Total Impact (ug/m^3)	NO_X MERP (tpy)	NO_X Impact (ug/m^3)	SO_2 MERP (tpy)	SO_2 Impact (ug/m^3)	Total Impact (ug/m^3)
2,218	0.11	623	0.002	0.11	9,647	0.004	4,014	3.98E-05	0.004

2.3.2 Significant Impact Levels

The first stage of an ambient air quality analysis is to determine whether the potential exists for a source's emission to cause or contribute to a violation of the NAAQS or PSD Increment. This stage of the analysis compares the primary and secondary impacts of the source to the relevant SILs to determine if the source will have a "significant impact" on air pollutant concentrations and establish whether a NAAQS or PSD Increment modeling analysis is required. The SILs were previously presented in Table 2-3. The Project's O&M emissions have been divided into specific operating scenarios that are described further in Section 3.

2.3.3 National Ambient Air Quality Standards Comparison

If impacts from the Project's O&M emissions are above the NAAQS SILs, a comparison will be done to the NAAQS to ensure air quality standards will not be exceeded. The NAAQS are provided in Table 2-2. The pollutants and averaging periods that would be compared to the NAAQS if its' respective SIL were exceeded include: 1-hour and 8-hour CO, 1-hour and annual NO_2, 24-hour and annual $PM_{2.5}$, and 24-hour PM_{10}. As part of the modeling analysis, background concentrations from a representative monitor will be added to the modeling results to compare against the NAAQS. NAAQS comparison will be performed for each of the O&M scenarios described in Section 3.

2.3.3.1 Background Air Quality

For modeled impacts greater than the SIL, model concentrations due to emissions from the Project will be added to ambient concentrations to obtain total concentration impacts at receptors. These total concentrations will be compared to the NAAQS and Massachusetts Ambient Air Quality Standards (MAAQS). To conservatively estimate the background pollutant concentration levels in the Project's lease area, the most recent air quality monitoring data available were used.

Background concentrations were determined from air quality monitoring stations with selection criteria based both on proximity to and representativeness of the RWF. The most representative monitoring site for $PM_{2.5}$ is also the closest monitoring site, which is located at the EPA Laboratory in Narragansett, Rhode Island (AQS Site ID 44-009-0007). The most representative monitoring site for CO and NO_2 is in East Providence, Rhode Island at the Francis School (AQS ID 44-007-1010). The most representative monitoring station for PM_{10} is located at the Community College of Rhode Island Liston Campus rooftop in Providence, Rhode Island (AQS ID 44-007-0022) (EPA, 2021c).

Given that the RWF is mostly distant from anthropogenic emission sources, use of these predominantly urban and suburban air monitoring stations for establishing background concentrations are anticipated to be conservative in nature. Table 2-6 provides a summary of the background air monitoring concentrations based on 2018 through 2020 data.

Table 2-6 Ambient Air Monitoring Concentrations and Selected Background Levels (ug/m^3)

Pollutant	Averaging Period	2018	2019	2020	Selected Background Level	NAAQS/ MAAQS
CO	1-hour	1,437	1,801	1,491	1,801	40,000
	8-hour	916	1,031	1,145	1,145	10,000
NO_2	1-hour	70.0	77.9	74.7	74.2	188
	Annual	12.2	12.4	11.6	12.4	100
$PM_{2.5}$	24-hour	16.8	12.8	13.9	14.5	35
	Annual	5.4	3.9	4.0	4.4	12
PM_{10}	24-hour	23.0	23.0	20.0	23.0	150

2.3.3.2 NAAQS Cumulative Impact Analysis

Typically, when a NAAQS SIL is exceeded, the subsequent modeling to demonstrate compliance with the NAAQS would require cumulative modeling of nearby sources if they cause a significant concentration gradient in the vicinity of the Project and are not adequately represented by background monitoring data. The importance of a significant concentration gradient in the identification of nearby sources is from the understanding that if a source causes an area to have a sharp gradient between pollutant concentrations, then these localized elevated concentrations are not likely to be sufficiently represented within monitored background data.

EPA provides further clarification on what constitutes a significant concentration gradient in a March 1, 2011 memorandum titled *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard* (the Memorandum) (EPA, 2011). There it is discussed that “Concentration gradients associated with a particular source will generally be largest between the source location and the distance to the maximum ground-level concentrations from the source.” It goes on to say that beyond the maximum impact distance, concentration gradients will generally be much smaller and more spatially uniform. EPA then considers the relationship between stack height and the distance to the maximum impact. EPA acknowledges that a 1-hour averaging period is likely to have the most significant concentration gradients, whereas annual concentration gradients would likely be smaller and more spatially uniform. A general rule of thumb is provided for estimating distances to maximum 1-hour impacts in relatively flat terrain, which is to assume the maximum 1-hour impact, or the significant concentration gradient, occurs at a distance that is approximately 10 times the source release height. For longer averaging periods, this distance is smaller. EPA also acknowledges that “even accounting for some terrain influences on the location and gradients of maximum 1-hour concentrations, these considerations suggest that the emphasis on determining which nearby sources to include in the modeling analysis should focus on the area within about 10 kilometers of the project location in most cases…”

Revolution Wind does not expect to perform any cumulative modeling of on-land sources for the following reasons:

1. Comparisons to the NAAQS will incorporate background air monitoring data from a combination of air monitoring stations in Rhode Island. Considering the distance between Revolution Wind's nearest proposed WTG and mainland Rhode Island is 11 nm [21 km], it can be assumed that any influence from coastal Rhode Island sources will already be conservatively accounted for in the background air monitoring data.

2. The nearest onshore area which is approximately 7.4 nm [13.7 km] from the nearest proposed WTG is Nomans Land Island off Martha's Vineyard, which has no sources of emissions.

3. Martha's Vineyard, which is 10 nm [18 km] from the nearest proposed WTG has three reportable sources: two GenOn Canal LLC power generating plants, and a hot mix asphalt plant (MassDEP, 2022). The hot mix asphalt plant produces an insignificant contribution to the Project's most dominant pollutant, NO_X. Therefore, the only other sources on Martha's Vineyard are the GenOn Power Plants; one located in West Tisbury and the other in Oak Bluffs.

   Martha's Vineyard's primary energy source is provided to the island via four 23.2-kilovolt underwater cables. The GenOn power plants supplement this power supply during peak demand. According to the Facilities' Massachusetts Operating Permits, in a typical year the units operate fewer than 1,000 hours each, and some units operate fewer than 100 hours.[1] The two GenOn power plants have a total of five 2.5 MW generators, each with a brake horsepower of 3,600 bhp. According to their permits, the NO_X emission limit when operating for less than 1,000 hours per year is 9.0 g/bhp-hr, and the NO_X emission limit when operating for more than 1,000 hours per year is 2.3 g/bhp-hr.

   A 2021 article published in the *Vineyard* Gazette included fuel consumption estimates needed to keep up with electricity demand on the island for the following five years. The estimate by Rob Hannemann, engineer and former Tufts professor who lives in Chilmark and has been a leader on the climate action committee, was between 300,000 and 500,000 gallons per year.[2] Each of the generators have a fuel consumption rate of 209 gallons per hour; therefore, the total required usage to meet this demand for all five generators is a combined 2,392 hours, or 478 hours each when divided evenly over the five generators.

   Therefore, the emissions from these two facilities are conservatively calculated assuming that each of the five units will operate for 1,000 hours (a total of 5,000 hours) with a NO_X emission factor of 9.0 g/bhp-hr. Under this conservative scenario, the total emissions from the five 3,600 bhp generators would be equal to 179 tons per year, or 86% of Revolution Wind's estimated O&M emissions. Based on this relationship, it is estimated that Revolution Wind's NO_X significant impact radius would need to extend out to at least 10 km to overlap with that of GenOn Canal's.

   In addition to the distance between the Project and the sources being greater than the 10 km discussed above, the prevailing wind direction on Martha's Vineyard is predominantly out of the west (see Revolution Wind's *Meteorological Data and Air Dispersion Modeling Comparisons* Study in Appendix A of the Construction Protocol), which means that the plumes from these three sources will be blown away from the Project. Since Revolution Wind does not expect any of the O&M

[1] Transmittals X259640 and X259641
[2] https://vineyardgazette.com/news/2021/07/22/undersea-cable-fails-highlighting-stress-vineyard-energy-grid

emissions to have significant impact areas (SIAs) of more than a few km, it is assumed that no significant interaction will occur between the sources.

4. The are no reportable sources on Block Island to the west (the direction from which prevailing winds will blow towards the Project); therefore, it can be reasonably assumed that the use of onshore background air monitoring data is a conservative method to account for onshore sources in the Project area.

Regarding offshore sources, the only two potentially interactive sources are Vineyard Wind Farm and South Fork Wind Farm. Since these sources are not yet operational, and because there are no offshore air monitoring stations at these sites, there is no available background air monitoring data to account for these sources' emissions.

The results of Vineyard Wind's O&M Significant Impact Level Modeling were presented in their April 22, 2019 *Vineyard Wind Project, Supplemental Information Requested by EPA Region 1, Construction and O&M Stage Modeling* Memorandum (VWF, 2019). It was found that their O&M phase exceeded the NAAQS SILs for three pollutant averaging periods: 1-hour NO_2, 24-hour $PM_{2.5}$, and 24-hour PM_{10}. The SIAs for the three pollutants were 1.0 km, 1.5 km, and 0.5 km, respectively. Considering that Revolution Wind will have similar O&M activities and has a similarly sized Project, the SIAs determined from Revolution Wind's air quality analysis is expected to be similar in radius. Since Revolution Wind is about 19 km away from Vineyard Wind at their nearest points, it can be reasonably expected that Vineyard Wind's SIAs will not overlap with any SIAs found during the O&M modeling of Revolution Wind.

The results of South Fork Wind's O&M Significant Impact Level Modeling were presented in their September 2020 *Outer Continental Shelf Permit – Air Quality Impact Modeling Report for Operations and Maintenance Emissions* report (SFWF, 2020). It was found that their O&M phase exceeded the NAAQS SILs for three pollutant averaging periods: 1-hour NO_2, 24-hour $PM_{2.5}$, and 24-hour PM_{10}. The SIAs for the three pollutants were 4.5 km, 2.5 km, and 0.75 km. The results of their 1-hour NO_2 NAAQS modeling results presents a highest 3-year average of annual 98th percentile 1-hour daily maxima of 42.8 ug/m^3. Their 24-hour $PM_{2.5}$ NAAQS modeling results presents a highest 3-year average of annual 98th percentile 24-hour concentrations of 4.43 ug/m^3. The highest second-highest annual 24-hour PM_{10} concentration is 9.21 ug/m^3.

Because South Fork's 1-hour NO_2 maximum impacts are based on their Scenario 2 modeling, which only occurs 14 days per year every other year, the 1-hour NO_2 modeled impacts are caused by an intermittent source, per EPA's definition in their March 1, 2011 Memorandum (EPA, 2011). In the Memorandum, it reads "'[i]t is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled.' While we recognize that these intermittent emission sources could operate at the same time as the primary source(s), the discussion above highlights the additional level of conservatism in the modeled impacts inherent in an assumption that they do in fact operate simultaneously and continuously with the primary source(s)." Although this guidance supports excluding the South Fork Scenario 2 emissions, Revolution Wind will take a conservative initial approach as outlined below.

To evaluate whether additional analysis is necessary for 1-hour NO_2, 24-hour $PM_{2.5}$ and PM_{10}, for any NAAQS SILs that are found to be exceeded by both Revolution Wind and South Fork Wind, Revolution Wind proposes combining the SIL impacts presented in South Fork Wind's O&M Modeling Report with Revolution Wind's modeled SIL impacts and background concentrations and comparing those totals to the NAAQS. This method is conservative because it takes worst-case impacts for both projects and combines then without consideration for temporal and spatial. Table 2-7 presents the concentrations to which Revolution Wind's NAAQS impacts will be compared to determine whether further analysis is needed.

Table 2-7 O&M NAAQS Model Impacts Thresholds for Cumulative Modeling (ug/m^3)

Pollutant	Averaging Period	NAAQS/ MAAQS	Selected Background Level	SFWF Impacts	Revolution Wind Modeling Threshold
NO_2	1-hour	188	74.2	44.9	68.9
$PM_{2.5}$	24-hour	35	14.5	8.35	12.15
PM_{10}	24-hour	150	23.0	13.28	113.72

2.3.4 Class II Prevention of Significant Deterioration Increments

If impacts from the Project's O&M emissions are above the PSD Increment SILs, a comparison will be done to the PSD Increments to ensure that they will not be exceeded. The PSD Increments are provided in Table 2-2. The pollutants and averaging periods that would be compared to the PSD Increments if its respective SIL were exceeded include: annual NO_2, 24-hour and annual $PM_{2.5}$, and 24-hour and annual PM_{10}.

2.3.4.1 PSD Increment Cumulative Impact Analysis

Similar to when a NAAQS SIL is exceeded through modeling, when a PSD Increment SIL is exceeded, the subsequent modeling to demonstrate compliance with the PSD Increment would require cumulative modeling of increment-consuming sources if the minor source baseline data has been triggered in the area. Therefore, sources that have been permitted since the minor source baseline date within a baseline area have to be accounted for to determine increment consumption. Similar to the methods used for determining when a NAAQS cumulative impact modeling analysis is required, determining whether any sources have a SIA that overlaps with the proposed source is the method for determining which sources, if any, should be included in a cumulative PSD Increment analysis.

As discussed in Section 2.2, Dukes Counties in Massachusetts are within 50 km (the model domain) of the Project Area subject to the OCS Permit. Based on consultation with the Massachusetts Department of Environmental Protection (MassDEP) and EPA Region 1, the minor source baseline has not been triggered in Dukes County. Per EPA's Fact Sheet for SFWF's OCS Air Permit, "…EPA considers the lease area as the baseline area for which the minor source baseline is set…" (EPA, 2021a) Therefore, the minor source baseline date for NO_2 and $PM_{2.5}$ in SFWF's Lease Area OCS-A 0517 is January 13, 2021. Similarly, the minor source baseline date for Vineyard Wind's Lease Area OCS-A 0501 is January 29, 2019 and was set for NO_2, CO, PM_{10} and $PM_{2.5}$.

As described in Section 2.3.3.2, Vineyard Wind's Class II SIAs are well removed from Revolution Wind and are not expected to have overlapping SIAs. Therefore, Revolution Wind does not expect to perform modeling of Vineyard Wind emissions.

When South Fork Wind (SFW) performed its PSD Increment O&M modeling, two scenarios were modeled: Scenario 1 and Scenario 2. Scenario 1 represented daily O&M activity. Scenario 2 is representative of larger-scale repairs that will not occur on a set schedule, but were modeled as continuous sources for three years of meteorological data, although this activity is only anticipated to occur for 14 days every 2 years. Therefore, emissions sources that only have a 1.9% chance of occurring in any 24-hour period were modeled as though they would occur continuously. Furthermore, the continuous Scenario 2 emissions modeling also assumed that two feeder barges would be used despite the following language in the O&M Modeling Report: "…it is unlikely that two feeder barges will be necessary for a large-scale repair project, but both were included in the modeled scenario to provide flexibility for SFW."

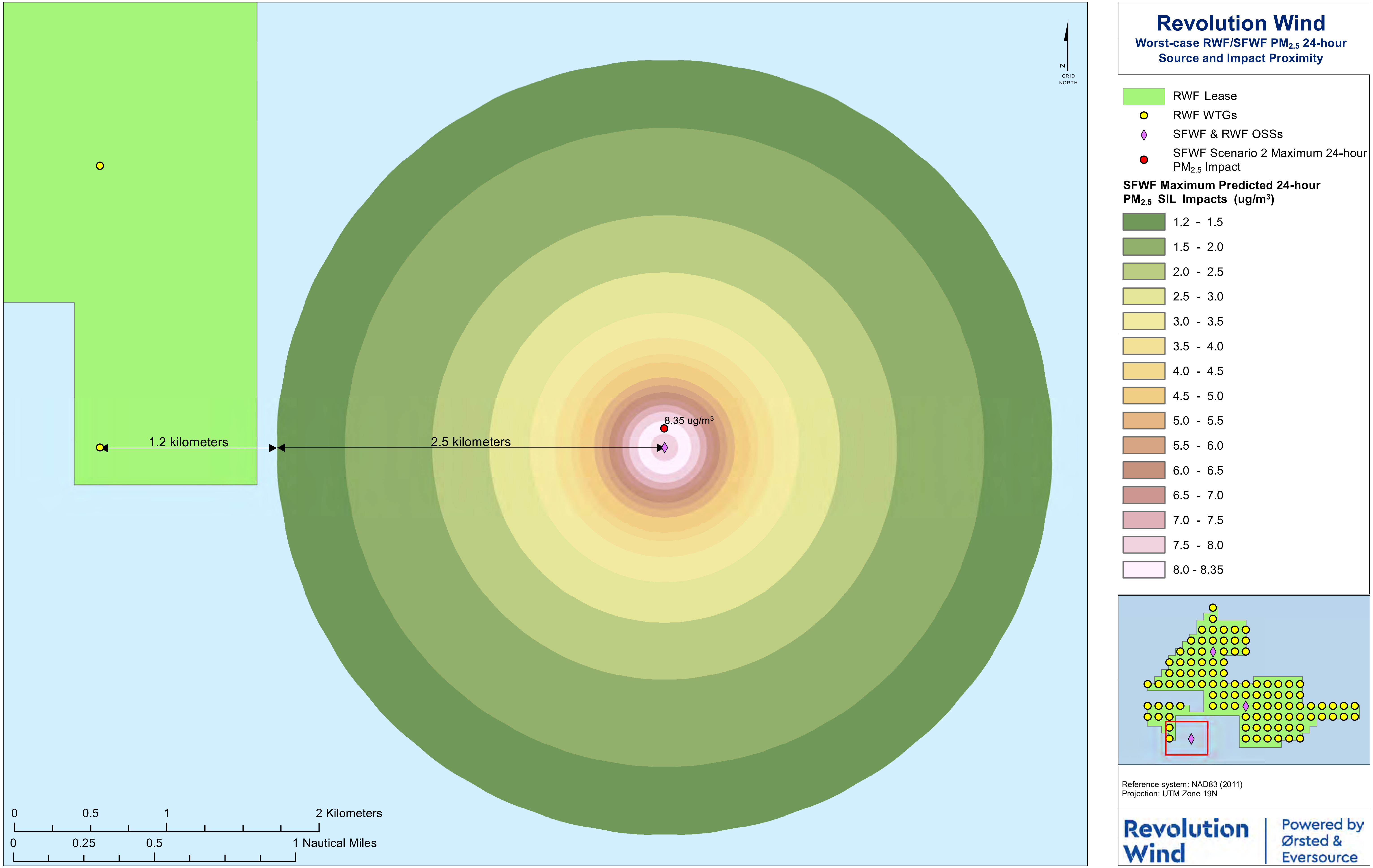
The Scenario 1 modeling did not exceed any of the Class II SILs. The continuous modeling of Scenario 2 sources were found to exceed Class II SILs, specifically the 24-hour $PM_{2.5}$ and PM_{10} SILs of 1.2 μg/m^3 and 5 μg/m^3, respectively. The Scenario 2 Significant Impact Areas (SIA) for the 24-hour $PM_{2.5}$ and PM_{10} impacts were 2.5 km and 0.75 km, respectively. The SFW Scenario 2 modeling applied downwash dimensions to the jack-up and feeder barges. The dimensions used for downwash were representative of the SFW Offshore Substation (OSS). Therefore, the Scenario 2 SIA of 2.5 km originates from the SFW OSS. The nearest Revolution Wind WTG is 3.7 km from the SFW OSS, or 1.2 km from the edge of the SFW 24-hr $PM_{2.5}$ SIA. See Figure 2-1.

The first approach for evaluating the potential cumulative 24-hour $PM_{2.5}$ Increment impacts between SFW and Revolution Wind will be to determine the extent of the Revolution Wind SIA if it were to originate from the WTG nearest to the SFW OSS and whether it overlaps with the SFW SIA in Figure 2-1. This is a very conservative approach for a few reasons:

- It assumes that the worst-case 24-hour Revolution Wind emissions occur at the same time as the worst-case SFW 24-hour emissions (which only have a 1.9% chance of occurring in any 24-hour period),
- It assumes that these worst-case emissions would occur as close as possible out of the many square kilometers of lease area between these two projects, and
- It assumes that these worst-case emissions that are occurring as close as possible are also occurring on the worst day of dispersion.

It is likely that this conservative approach will result in an overlap of the Revolution Wind and SFW 24-hour $PM_{2.5}$ SIAs. However, just because these two SIAs indicate some overlap does not mean that additional modeling is necessary to demonstrate compliance with the 24-hour $PM_{2.5}$ PSD Increment. For example, if the Revolution Wind SIA were to be 2 km in diameter, but the overlapping portions of the SIAs are below 9 $\mu g/m^3$, it can be assumed that the PSD Increment is not exceeded. This approach is conservative because the SIA in Figure 2-1 represents SFW's the maximum impacts in any given direction for each ring of receptors. Therefore, even though the modeled SFW 24-hour $PM_{2.5}$ SIL exceedances primarily extend north of the SFW OSS, it is assumed that the maximum impacts extend in all directions from the source.

If Revolution Wind's 24-hour $PM_{2.5}$ modeling were to find that the SIAs could overlap, and the overlapping concentrations exceed 9 $\mu g/m^3$, cumulative modeling would be necessary. EPA and Revolution Wind have engaged in many discussions on how to represent SFW in cumulative modeling given how conservative SFW's Scenario 2 is. After consulting with its Office of Air Quality Planning and Standards (OAQPS), EPA recommended that the SFW Scenario 1 emissions be included in the PSD Increment cumulative modeling, which is the more typical of SFW's operating scenarios. If this approach is taken (due to the above approaches being inconclusive) then SFW's secondary $PM_{2.5}$ increment consumption from Scenario 1 emissions will also be included in the cumulative analysis.



Revolution Wind
Worst-case RWF/SFWF $PM_{2.5}$ 24-hour Source and Impact Proximity
RWF Lease
RWF WTGs
SFWF & RWF OSSs
SFWF Scenario 2 Maximum 24-hour $PM_{2.5}$ Impact
SFWF Maximum Predicted 24-hour $PM_{2.5}$ SIL Impacts (ug/m^3)
1.2 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
5.0 - 5.5
5.5 - 6.0
6.0 - 6.5
6.5 - 7.0
7.0 - 7.5
7.5 - 8.0
8.0 - 8.35
8.35 ug/m^3
1.2 kilometers
2.5 kilometers
N
GRID NORTH
0 0.5 1 2 Kilometers
0 0.25 0.5 1 Nautical Miles
Reference system: NAD83 (2011)
Projection: UTM Zone 19N
Revolution Wind
Powered by Ørsted & Eversource

2.4 Class II Air Quality Related Values Assessments

2.4.1 Visibility

The Lye Brook Wilderness Area in Southern Vermont is the closest Class I area to RWF. Lye Brook is located approximately 252 km to the northwest of the Project. The Brigantine Wilderness Area in New Jersey is approximately 310 km to the southwest of the Project. The U.S. Forest Service (USFS) have requested that a Visibility analysis be performed for construction emissions using CALPUFF. A protocol for this analysis has been prepared for and approved by the USFS. Therefore, considering that the O&M emissions are only 5% of the construction emissions, the results of the construction phase Visibility modeling will imply compliance for the O&M emissions.

A screening visibility analysis will be conducted for Class II vistas using the EPA VISCREEN model for Class II vistas at Block Island and Martha's Vineyard. The worst-case annual emission rates for NO_x and particulate matter will be used for the analysis.

2.4.2 Soils and Vegetation

PSD Regulations require analysis of air quality impacts on sensitive vegetation types with significant commercial or recreational value or sensitive types of soil. Evaluation of impacts on sensitive vegetation will be performed by comparison of predicted Project impacts with screening levels presented in *A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils and Animals* (EPA, 1980). These procedures specify that predicted impacts concentrations used for comparison account for Project impacts and ambient background concentrations.

Most of the designated vegetation screening levels are equivalent to or exceed NAAQS and/or PSD increments, so that satisfaction of NAAQS and PSD Increments assure compliance with sensitive vegetation screening levels.

2.4.3 Growth

The Project must assess the impact of emissions from secondary growth during O&M. This assessment will use reports produced for the Project's COP (RWF, 2021a).

2.5 State Requirements

OCS sources located within RWF are subject to the federal, state, and local requirements of the COA set forth in 40 CFR 55.14. In the Project's Notice of Intent (NOI), RWF identified Massachusetts as the COA since EPA did not receive a request from any neighboring state's air pollution control agencies to be designated as the COA within 60 days (RWF, 2021b).

The relevant Massachusetts regulations on air modeling center on documenting that the Massachusetts MAAQS are not being violated. The MAAQS are codified in 310 CMR 6.00 and after being updated in 2019 now follow the NAAQS. The MAAQS are presented in Table 2-8.

Table 2-8 Massachusetts Ambient Air Quality Standards

Pollutant	Averaging Period	MAAQS (ug/m^3)	
		Primary	Secondary
CO	1-hour	40,000[1]	-
	8-hour	10,000[1]	-
NO_2	1-hour	188[2]	188[2]
	Annual	100[3]	100[3]
$PM_{2.5}$	24-hour	35[4]	35[5]
	Annual	12[5]	15[5]
PM_{10}	24-hour	150[1]	150[1]
SO_2	1-hour	196[6]	-
	3-hour	-	1,310[1]
Ozone	8-hour	137.4[7]	137.4[7]
Lead	Rolling 3-month average	0.15[8]	0.15[8]

[1] Not to be exceeded more than once per year
[2] 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[3] Annual mean
[4] 98th percentile, averaged over 3 years
[5] Annual mean, averaged over 3 years
[6] 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
[7] Annual fourth-highest daily maximum ozone concentration, averaged over 3 years
[8] Not to be exceeded

2.6 Summary of Modeling Requirements

Table 2-9 describes the various modeling requirements applicable to the Project's emissions during construction (detailed in accompanied Construction Protocol) and O&M.

Table 2-9 Summary of Modeling Requirements

Modeling Requirements	Construction Emissions		O&M Emissions
PSD Class I SIL Analysis	**Yes**	**Yes**	No
Secondary Formation of $PM_{2.5}$	**Yes**	**Yes**	**Yes**
Ozone Analysis	No	No	No
SIL Analysis for NAAQS and PSD Class II Areas	No	No	**Yes**
NAAQS Cumulative Modeling of South Fork Wind	No	No	**If Table 2-7 exceeded**
PSD Increment Analysis	No	No	**If Class II SILs exceeded**
Visibility Assessment	No	No	**Yes**
Soils and Vegetation	No	No	**Yes**
Growth	No	No	**Yes**

3.0 AIR QUALITY IMPACT ANALYSIS

The Project emissions air quality analysis for the O&M phase is discussed in this section. Impacts of criteria emissions will be modeled for comparison to ambient air quality standards discussed in Section 2.

The dispersion modeling analysis is separated into two distinct components:

1) The source impact analysis using SILs, and
2) The NAAQS/MAAQS and PSD Increment analysis.

In the source impact analysis, the emissions of contaminants subject to PSD review from the O&M activities will be modeled. The results of this analysis were used to determine which pollutants require a NAAQS/MAAQS and/or PSD Increment analysis (as necessary). If the results of the preliminary analysis indicate the emissions from the anticipated O&M activities and resulting emissions will not increase ambient concentrations by more than pollutant-specific SILs, no further modeling is required.

3.1 Justification to Use Significant Impact Levels

The use of SILs are appropriate if the difference in background concentrations for a specific pollutant and averaging period, and the applicable NAAQS are greater than the applicable SIL. Table 3-1 summarizes the difference between the NAAQS and the monitored background concentration. As shown in Table 3-1, all averaging periods for each pollutant have differences between the monitored value and the NAAQS, which is greater than the respective SIL; therefore, the use of the SILs are appropriate as screening criteria as a project impact equal to or less than the SIL will result in a concentration less than the NAAQS.

Table 3-1 Difference Between NAAQS and Background Concentrations Compared to SILs (ug/m^3)

Pollutant	Averaging Period	NAAQS	Selected Background	NAAQS – Background Delta	Class II SILs	Delta Greater than SILs?
CO	1-hour	40,000	1,801	38,199	2,000	Yes
	8-hour	10,000	1,145	8,855	500	Yes
NO_2	1-hour	188	74.2	113.8	7.5	Yes
	Annual	100	12.4	87.6	1	Yes
$PM_{2.5}$	24-hour	35	14.5	20.5	1.2	Yes
	Annual	12	4.4	7.6	0.2	Yes
PM_{10}	24-hour	150	23.0	127.0	5	Yes

3.2 Air Quality Model Selection and Options

The offshore and coastal dispersion (OCD) model is a near-field air dispersion model, appropriate for evaluating impacts at a distance up to 50 km from a source. The OCD model is currently the preferred model for overwater applications per Appendix W of 40 CFR 51. OCD is a straight-line Gaussian model that incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. The OCD model was selected because it is currently EPA's preferred model for overwater conditions.

3.3 Meteorological Data for Modeling

Meteorological data for the air dispersion modeling were extracted from three consecutive years of Weather Research and Forecasting (WRF) prognostic model data (2018-2020) obtained from EPA Region 1. The Mesoscale Model Interface (MMIF) program was used to extract the necessary meteorological parameters.

Data for the overwater points were extracted by EPA using the AERCOARE and AERMET output option. The AERCOARE output provides essential parameters that are unique to overwater environments. The overland points were extracted using the AERMET output, which extracts the parameters and files needed for to process the meteorological data through AERMET and produce SFC and PFL files. AERMET was executed using the input files that were provided by EPA from the MMIF outputs.

For use with the OCD model, the AERCOARE- and AERMET-formatted MMIF outputs were converted into OCD format using a Fortran program, "MMIF to OCD". The program was provided to Katherine Mears by Leiran Biton on July 10, 2020. Per Leiran Biton's email the program had been provided to EPA by Bart Brashers of Ramboll. The program contains two executable files; "aercoare2ocd", which converts AERCOARE-formatted data into an OCD5 overwater file, and "sfc2ocd", which converts data in AERMET .SFC format to a PCRAMMET ASCII file, which OCD5 recognizes. The "sfc2ocd" programs uses the Pasquill Gifford method for determining stability.

A detailed analysis of the meteorological data developed for the OCD modeling study is presented within Appendix A of the Construction Protocol, which is being submitted to EPA separately. These same data, (specifically the WRF data from the grid point nearest to the Project centroid for overwater data, and the WRF data from the grid point nearest to Martha's Vineyard airport for overland data) are to be used for the O&M emissions impact study as well.

The data developed for this dispersion modeling extends 3 years and would reasonably provide all combinations of meteorological conditions that would give rise to worst-case modeled impacts. The data used are recent and represent current local climatology.

3.4 Modeling Methodology

For all modeled activities, Revolution Wind has made a good-faith effort to identify the most likely operating scenarios, generally choosing the scenario with more and larger air emissions sources where multiple options exist. Additionally, Revolution Wind has tried to determine representative source parameters for the types of ships that may be used for the activities described in the following sections. Final construction and O&M methods may differ as the Project design and logistical factors progress and implementation plans are refined. Refer to Table 2-6 for the proposed background air monitoring data to be used for the NAAQS modeling analysis.

3.4.1 Operations and Maintenance Activities

The air modeling will focus on the daily routine O&M activities occurring within the RWF lease area and along the transit routes between the Ports of Call and RWF. Infrequent maintenance and repair activities are included in the analysis, although they are anticipated to occur only a few times over the life of the Project. Large-scale turbine or cable rehabilitation is not considered in the modeling as these activities are neither anticipated nor routine; and the labor, schedule duration, and vessel needs would not be known in advance.

Table 3-2 lists the typical O&M activities that are anticipated to occur annually and the number of days each vessel is expected to be used for the activities. For modeling against annual standards, the expected number of days of usage are incorporated into the emission estimates. For short-term averaging periods, it is conservatively assumed that vessels are operating continuously over that period of time (1-hour or 24-hours).

The Revolution Wind OSSs will primarily be powered via shore power. The RWEC will be a bi-directional cable, meaning that power can flow to or from the wind farm. The power required to operate the Project, known as station power or auxiliary power, is normally taken from the electricity generated by the Revolution Wind WTGs, when they are operating normally. During periods when the wind is not sufficient for the WTGs to operate normally, or if the WTGs are not operating for other reasons, Revolution Wind may draw power from the grid (through the export cable) for the Project and its various systems and components.

If shore power is not available, Revolution Wind must use alternative sources for the Project components. The Project design has incorporated an alternative power source within the WTGs. Specifically, WTGs will be equipped with an integrated battery backup system that can provide auxiliary power to the WTGs in the event of a temporary outage. The battery backup system can be charged by the WTG when operating. In the unlikely scenario where shore power from the grid is not available, the WTGs are not producing electricity, and the battery is insufficient to provide the necessary auxiliary power to the WTG, a temporary diesel generator would be used. Finally, an on-site diesel generator will be installed on each OSS if shore power is not available, and the WTGs are not providing power to the OSS. These generators will be used under emergency conditions to provide power to the OSS if grid power is unavailable or the maintenance being performed requires disconnection from the grid.

Testing of the emergency generators will occur for approximately 1 hour per week, and it is not expected that the emergency generator testing located at the OSS will occur simultaneously with the usage of other equipment. During WTG or OSS repair procedures, it is expected that a power source may be required for various purposes such as to operate power tools. Additional use of the OSS generators may occur for routine maintenance power where power grid is not available, and it is assumed that total operation of each OSS generator will not exceed 500 hours per year. No other generators are planned for the O&M phase outside of an extremely unlikely scenario if there were to be a grid outage, the WTGs were unable to produce power, and the integrated battery backup system was affected by a fault or otherwise lacked sufficient power.

There are four scenarios that are expected to occur during the O&M phase of the Project. These scenarios include:

1) routine daily inspections and maintenance,
2) nonroutine infrequent repairs of WTGs and OSSs,
3) routine infrequent array cable and foundation surveys, and
4) routine infrequent export cable surveys
5) nonroutine infrequent repairs of cables

Vessel and equipment activity in Scenarios 1 and 2 will be occurring at the OSSs and WTGs. The use of survey vessels for O&M Scenarios 3 and 4 will occur along the cable routes. Both scenarios 3 and 4 include the same vessels (see table 3-2) but at slightly different locations. Scenario 3 is the more conservative scenario and was selected for modelling, while scenario 4 will not be modelled. Scenario 5 will also be occurring along the cable routes. OSS emergency generators will be considered as part of all non-daily operating scenarios.

Each vessel was calculated using either BOEM default engine ratings and emission factors, or in a few cases, using vessel specific engine ratings and Tier-specific emission factors. An example calculation for on-site (non-transit) short-term $PM_{2.5}$ emissions from the SOV auxiliary engine is below, which uses a Tier 4 emission factor, BOEM default engine ratings and a BOEM default load factor. This is the only O&M vessel emission calculation that uses a Tier 4 emission factor. The CTVs use an IMO Tier II emission factor for NO_X. All other O&M vessels use a BOEM default emission factor.

$$0.310\,\frac{g}{kWhr}\;x\;201\;kW\;x\;1.0\;x\;\frac{1\;hr}{3600\;s} = 0.0173\;g/s$$

For dynamic positioning vessels (all except CTVs, SOV daughter and jack-up), the main/propulsion engines are also calculated for on-site emissions and combined with the auxiliary engine emissions when determining on-site modeling emission rates. Below is an example of the short-term $PM_{2.5}$ emissions from the SOV main/propulsion engines, which uses a Tier 4 emission factor, vessel-specific engine ratings and a BOEM default load factor.

$$0.250\,\frac{g}{kWhr}\,x\;6920\;kW\;x\;0.2\;x\;\frac{1\;hr}{3600\;s} = 0.0961\;g/s$$

For 1-hour NOX and long-term emissions calculations, the emission factors are also based on the number of hours per year they would be emitting at that location, divided by 8,760 hours. A description of the four modeled O&M operating scenarios and vessels involved are presented in the following subsections. Figures depicting the O&M source scenario configurations and the corresponding receptor grids are provided in Appendix A.

Table 3-2 Annual Vessel and Generator Use During Operations and Maintenance

Purpose/Scenario	Emissions Source	Number Of Sources	Propulsion Engine Rating (kW)	Auxiliary Engine Rating (kW)	Days of Usage per Year[3]
Scenario 1: Routine Inspections and Maintenance	Service Operations Vessel	1	6920[2]	201[2]	180
	Crew Transport Vessel	1	2,204[1]	201[1]	180
	SOV Daughter	1	3,013[1]	201[1]	75
Scenario 2: Non-routine WTG and OSS Repair	Crew Transport Vessel	1	2,204[1]	201[1]	12.5
	Jackup Vessel	1	22,400[1]	895[1]	12.5
	Jack-up Generator	1	NA	5	12.5
	Jack-up Generator	1	NA	100	12.5
	Jack-up Cherry Picker	1	NA	10	12.5
Scenario 3 & 4: Surveys	Crew Transport Vessel	1	2,204[1]	201[1]	21.5
	Routine Survey Vessel	1	16,637[2]	1,363[2]	26.7
Scenario 5: Cable Repairs	Cable-laying Vessel	1	16,637[2]	1,363[2]	31
	Cable Burial Vessel	1	16,637[2]	1,363[2]	31
All Scenarios: OSS Emergency	OSS Emergency Generators	2	NA	455	500 hours

[1] Only auxiliary engine used for on-site emissions for anchored/moored vessels. Propulsion and auxiliary engine included in transiting emission.
[2] Auxiliary and propulsion engines included for on-site and transiting emissions.
[3] Note that "Days of Usage per Year" means the maximum anticipated usage in any year. Many of these activities are not expected to occur every year.

3.4.2 Non-routine Infrequent Array Cable and Foundation Surveys (Scenario 3)

The RWEC, IAC, and OSS-Link Cable typically have no maintenance requirements unless a fault or failure occurs. To evaluate integrity of the assets, Revolution Wind intends to conduct an as-built survey/bathymetry survey along the entirety of the cable routes immediately following installation (scope of installation contractor). Bathymetry surveys will be performed one year after commissioning, two to three years after commissioning, and five to eight years after commissioning. Survey frequency thereafter will depend on the findings of the initial surveys (i.e., site seabed dynamics and soil conditions). A survey may also be conducted after a major storm event (i.e., greater than 10-year event). Surveys of the cables may be conducted in coordination with scour surveys at the foundations.

Should the periodic bathymetry surveys indicate that the cables no longer meet an acceptable burial depth (as determined by the Cable Burial Risk Assessment), the following actions may be taken:

- Alert the necessary regulatory authorities, as appropriate;
- Undertake an updated cable burial risk assessment to establish whether cable is at risk from external threats (i.e., anchors, fishing, dredging);
- Survey monitoring campaign for the specific zone around the shallow buried cable; and
- Assess the risk to cable integrity.

The vessels and air emissions sources involved in array cable and foundation surveys are listed in Table 3-2. The exact size and nature of the vessels and equipment to be used could vary based on availability and the work required. However, the emissions and modeling are based on the number of vessels and size of engines as listed above in Table 3-2. These are conservative estimates of total engine kilowatt-hours and fuel usage that will be used, and therefore will lead to conservative estimates of Project impacts. It includes emissions from large vessels/engines and therefore will likely have the highest impact of any of the scenarios. Additional O&M activities are discussed below.

Short-term emissions assume continuous use of the survey vessel's auxiliary and propulsions engines. For the CTV's short-term emissions, continuous use of the CTV's auxiliary engine is assumed. Propulsion and auxiliary engine emissions will be applied to the transit emissions of these vessels, which will only be modeled for annual criteria. The jack-up vessel's generators and equipment are assumed to be continuous while not in transit. It is also assumed in this scenario that the OSS generators are in continuous full load use. Table 3-3 provides a summary of the sources' stack parameters and Table 3-4 provides the sources' emission rates while on site. Transiting emissions are provided in Section 3.4.6. The building height and width are parameters that will be used by the OCD model to calculate downwash, which was determined to be appropriate for repair activities at the OSS.

Table 3-3 Routine Array Cable Surveying Model Stack Parameters

Vessel/Equip. Type	Building Height (m)	Stack Height (m)	Stack Temp. (K)	Stack Diam. (m)	Stack Velocity (m/s)	Stack Angle	Platform Elevation (m)	Width of Building (m)
CTV	0.0	10.0	555	0.33	20.0	0	0.0	0.0
Survey Vessel	0.0	30.0	800	0.60	6.6	0	0.0	0.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0

Table 3-4 Routine Array Cable Surveying Modeling Emission Rates (g/s)

Vessel/Equip. Type	CO	Annual NO_X	1-hour NO_X	Annual $PM_{2.5}$	24-hour $PM_{2.5}$	Annual PM_{10}	24-hour PM_{10}
CTV	0.14	0.014	0.014	0.00034	0.017	0.00035	0.018
Survey Vessel	3.0	0.95	0.95	0.0028	0.42	0.0029	0.43
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018

3.4.3 Non-routine Infrequent Cable Repairs (Scenario 5)

Based on the outcome of the surveys described in Scenario 3, several options may be undertaken, as feasible, permitted and practical:

- Remedial burial if feasible and practical;
- Secondary protection (rock protection, rock bags or mattresses); and/or
- Increased frequency of bathymetry surveys to assess reburial.

It is possible submarine cables may need to be repaired or replaced due to fault or failure. Also, it is expected that a maximum of 10 percent of the cable protection placed during installation may require replacement/remediation over the lifetime of the Project. These maintenance activities are considered non-routine and are only expected to occur 3 times over the Project lifetime.

The vessels and air emissions sources involved in cable repairs are listed in Table 3-2. The exact size and nature of the vessels and equipment to be used could vary based on availability and the work required. However, the emissions and modeling are based on the number of vessels and size of engines as listed above in Table 3-2. These are conservative estimates of total engine kilowatt-hours and fuel usage that will be used, and therefore will lead to conservative estimates of Project impacts. It includes emissions from large vessels/engines and therefore will likely have the highest impact of any of the scenarios. Additional O&M activities are discussed below.

Short-term emissions assume continuous use of the cable burial and laying vessels' auxiliary and propulsions engines. Propulsion and auxiliary engine emissions will also be applied to the transit emissions of these vessels, which will only be modeled for annual criteria. It is also assumed in this scenario that the OSS generators are in continuous full load use. Table 3-5 provides a summary of the sources' stack parameters and Table 3-6 provides the sources' emission rates while on site. Transiting emissions are provided in Section 3.4.6. The building height and width are parameters that will be used by the OCD model to calculate downwash, which was determined to be appropriate for repair activities at the OSS.

Table 3-5 Non-routine Cable Repair Model Stack Parameters

Vessel/Equip. Type	Building Height (m)	Stack Height (m)	Stack Temp. (K)	Stack Diam. (m)	Stack Velocity (m/s)	Stack Angle	Platform Elevation (m)	Width of Building (m)
Cable Burial Vessel	0.0	30.0	800	0.60	6.6	0	0.0	0.0
Cable-laying Vessel	0.0	30.0	800	0.60	6.6	0	0.0	0.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0

Table 3-6 Non-routine Cable Repair Modeling Emission Rates (g/s)

Vessel/Equip. Type	CO	Annual NO_X	1-hour NO_X	Annual $PM_{2.5}$	24-hour $PM_{2.5}$	Annual PM_{10}	24-hour PM_{10}
Cable Burial Vessel	3.0	1.10	1.10	0.036	0.42	0.037	0.43
Cable-laying Vessel	3.0	1.10	1.10	0.036	0.42	0.037	0.43
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018

3.4.4 Non-routine Wind Turbine Generator and Offshore Substation Repair Activities (Scenario 2)

O&M for the WTGs is anticipated to include activities such as inspection of components and equipment, and replacement of components and gear box oil as necessary. Most O&M repair activities will require only the use of a single crew transport vessel.

Other O&M activities will require additional equipment due to the nature of the work. These O&M activities may include the use of a crew transport vessel (CTV) and jack-up vessel, in addition to two small on-vessel generators and a cherry picker. These O&M activities are anticipated to be infrequent and occur only approximately 2 to 3 times over the lifetime of the Project. The duration of these maintenance and repair excursions could last 12.5 days on average.

The vessels and air emissions sources involved in WTG/OSS larger scale repair are listed in Table 3-2. The exact size and nature of the vessels and equipment to be used could vary based on availability and the work required. However, the emissions and modeling are based on the number of vessels and size of engines as listed above and in Table 3-2. These are conservative estimates of total engine kilowatt-hours and fuel usage that will be used, and therefore will lead to conservative estimates of Project impacts. It includes emissions from large vessels/engines and therefore will likely have the highest impact of any of the scenarios. Additional O&M activities are discussed below.

Short-term emissions assume continuous use of the CTV's and jack-up vessel's auxiliary engines. Propulsion and auxiliary engine emissions will be applied to the transit emissions of these vessels which will only be modeled for annual criteria. The jack-up vessel's generators and equipment are assumed to be continuous while not in transit. It is also assumed that in this scenario one of the OSS generators is in continuous full load use. Table 3-7 provides a summary of the sources' stack parameters and Table 3-8 provides the sources' emission rates while on site. Note that the auxiliary equipment on the jack-up vessel presented in Table 3-2 is included within the jack-up vessel's model emission source. Transiting emissions are provided in Section 3.4.6. The building height and width are parameters that will be used by the OCD model to calculate downwash, which was determined to be appropriate for repair activities at the OSS.

Table 3-7 Non-routine WTG and OSS Repair Model Stack Parameters

Vessel/Equip. Type	Building Height (m)	Stack Height (m)	Stack Temp. (K)	Stack Diam. (m)	Stack Velocity (m/s)	Stack Angle	Platform Elevation (m)	Width of Building (m)
CTV	0.0	10.0	555	0.33	20.0	0	0.0	0.0
Jackup Vessel	16.0	20.0	555	1.00	3.3	0	17.0	80.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0
OSS Generator	8.0	30.0	758	0.33	39.4	0	25.0	80.0

Table 3-8 Non-Routine WTG and OSS Modeling Emission Rates (g/s)

Vessel/Equip. Type	CO	Annual NO_X	1-hour NO_X	Annual $PM_{2.5}$	24-hour $PM_{2.5}$	Annual PM_{10}	24-hour PM_{10}
CTV	0.14	0.014	0.014	0.00034	0.017	0.00035	0.018
Jackup Vessel	0.65	0.10	0.10	0.0029	0.084	0.0030	0.087
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018
OSS Generator	0.33	0.057	0.057	0.00021	0.018	0.00021	0.018

3.4.5 Daily Inspections and Maintenance Activities (Scenario 1)

For daily O&M, a crew transport vessel will be frequently used to transport crew to the Project for inspections, routine maintenance, and minor repairs. To support crew while on-site, a service operation vessel (SOV) will be used to provide accommodations. The SOV will have a generator and a SOV daughter craft will be used as needed to transport crew around RWF. The crew transport vessel will make trips approximately every other day to and from RWF and Ports of Call.

The short-term emissions of the SOV will be modeled assuming continuous use of the propulsion (i.e., main) engines and auxiliary engines. The short-term emissions of the SOV daughter craft and CTV will be modeled assuming use of the vessel's auxiliary engines. Propulsion and auxiliary engine emissions will be applied to transit emissions which will only be modeled for annual criteria. Table 3-9 provides a summary of the sources' stack parameters and Table 3-10 provides the sources' emission rates while on site. Transiting emissions are provided in Section 3.4.6.

Table 3-9 Routine Daily Inspections and Maintenance Model Stack Parameters

Vessel/Equip. Type	Building Height (m)	Stack Height (m)	Stack Temp. (K)	Stack Diam. (m)	Stack Velocity (m/s)	Stack Angle	Platform Elevation (m)	Width of Building (m)
CTV	0.0	10.0	555	0.33	20.0	0	0.0	0.0
SOV	0.0	30.0	555	0.60	6.6	45	0.0	0.0
SOV Daughter	0.0	5.0	555	0.33	20.0	0	0.0	0.0

Table 3-10 Routine Daily Inspections and Maintenance Modeling Emission Rates (g/s)

Vessel/Equip. Type	CO	Annual NO_X	1-hour NO_X	Annual $PM_{2.5}$	24-hour $PM_{2.5}$	Annual PM_{10}	24-hour PM_{10}
CTV	0.14	0.2	0.2	0.009	0.017	0.009	0.018
SOV	1.18	0.65	0.65	0.066	0.13	0.066	0.13
SOV Daughter	0.14	0.12	0.12	0.004	0.017	0.004	0.018

3.4.6 Transiting Vessels

Transit emissions for vessels moving between RWF and Ports of Call will not be modeled for short-term averaging periods as they will not remain in one place long enough to significantly impact any single receptor over that averaging period. Transiting emissions assume continuous use of both the propulsion (i.e., main) and auxiliary engines using maneuvering power. They will be modeled with 1 km spaced point sources, with a total of 40 point sources for Rhode Island and 46 for New York (see section 3.6 for more information on transit routes). Considering the 25 nm that the transiting vessels are assumed to travel while inside of the OCS Permit area, 1 km spacing for transiting point sources was requested by EPA Region 1 to represent the line of emissions associated with this activity without overburdening the model with point sources.

Table 3-11 provides a summary of the stack parameters assigned to transiting vessels. Transiting vessels are divided between routine and non-routine due to the significant difference in stack parameters of routine versus non-routine vessels. The stack parameters were chosen to conservatively represent the stacks of the several vessel types that the point sources represent.

Table 3-12 provides the transiting vessels emission rates which includes all O&M activity. It is conservatively assumed that all of the vessels could travel to either port. The emission rates for each point source vary between New York and Rhode Island due to the differing amount of point sources. The total emissions between the two scenarios are the same. Non-routine and routine vessels will be modeled together, and New York and Rhode Island will be modelled separately.

Table 3-11 Transiting Vessels Model Stack Parameters

Vessel/Equip. Type	Building Height (m)	Stack Height (m)	Stack Temp. (K)	Stack Diam. (m)	Stack Velocity (m/s)	Stack Angle	Platform Elevation (m)	Width of Building (m)
Transits	0.0	10.0	555	0.33	20.0	0	0.0	0.0

Table 3-12 Transiting Vessels Modeling Emission Rates (g/s)

Vessel/Equip. Type	Annual NO_X	Annual $PM_{2.5}$	Annual PM_{10}
Transits	0.30	0.013	0.013

3.4.7 Operation of the Engines Located on the Offshore Substation and Wind Turbine Generators

Likely as part of the daily O&M discussed in Section 3.4.5, the emergency engines located on the OSSs will be tested routinely for approximately 1 hour every week. These engines will operate intermittently during testing and occasionally when performing routine maintenance. It is assumed that each generator will operate for no more than 500 hours per year. There are no permanent emission sources located anywhere else on the OCS during the O&M phase of the Project.

The emissions and source parameters associated with these generators will be included in each scenario discussed in Section 3.4.2 and are included in Tables 3-3 through 3-8.

3.5 Nitrogen Oxide Conversion

The preliminary modeling will assume total conversion of NO_X to NO_2 (Tier 1). If this method shows NO_2 concentrations at receptors above the SIL, a Tier 2 ambient default NO_2/ NO_X ratio of 0.90 will be applied to the annual model results for comparison to the annual NO_2 criteria. For 1-hour NO_2 impacts (and possibly further refinements of annual NO_2 concentrations), NO_2 concentrations will be scaled according to a representative empirical relationship of ambient NO_2 to NO_X ratios will be applied to OCD model-predicted hourly NO_2 concentrations on an hour-to-hour basis. The hourly varying ambient ratio will be bounded by a minimum ratio of 0.5 to a maximum of 0.9.

3.6 Source Configuration of O&M Scenarios

The O&M activities will not occur on a set schedule and will depend on a multitude of factors, including weather conditions. Typically, the vessels will visit each of the WTGs and OSS, and survey the inter-array and export cables, but the time and sequence of visits to each location will vary. The vessels' positions will not be the same for each visit. Similarly, the OCD model can only assess impacts at stationary receptors. The most impacted nearby receptors are in locations where there cannot possibly be any residences, and where the public is unlikely to remain in one location for any extended period of time.

As discussed earlier, there are four OCS source O&M scenarios to be modeled:

1) routine daily inspections and maintenance,
2) nonroutine repairs of WTGs and OSSs,
3) routine cable surveys, and
4) non-routine cable repairs.

The vessel and equipment use associated with each scenario is provided in Table 3-2. In the short-term, each scenario is expected to occur separately and will be modeled separately for comparison to the relevant standards. In the long-term it is assumed that each O&M scenario will occur within the same year and will be modeled as such.

For Scenario 1, the short-term vessel activity will be modeled surrounding the location corresponding to the nearest WTG to land. For Scenario 2, the short-term vessel and OSS generator activity will be modeled surrounding the nearest OSS to land. For Scenario 3, the survey vessel is expected to survey 171 km of array cable within 26.7 days, equating to an average of 6.4 km per day. Therefore, the survey vessel emissions will be modeled as a point source located every 200 meters along the inter-array cables between the five WTGs nearest to shore, spanning 6,400 meters, for a total of 33 point sources. For Scenario 5, if found to be necessary the cable-laying and burial vessels would be performing this activity over large areas. This activity is only expected to occur 3 times over the Project lifetime and a maximum of 10% of the cable protection placed may require replacement/remediation over the Project lifetime. Therefore, a reasonable estimation for the daily range of this activity is to span the IAC between several WTGs. Therefore, the Scenario 5 activity will be modeled in the same fashion as Scenario 3, in 200 km increments along the IAC route between the five WTGs nearest to shore. In the case of short-term NO_X emissions, to represent the intermittent nature of these Scenarios, the O&M vessels were modeled based on the number of hours per year they would be emitting at that location, divided by 8,760.

It is expected that O&M transit routes may originate from any of the following ports:

- Port of Montauk, New York,
- Port Jefferson, New York,
- Port of Brooklyn, New York,
- Port of Davisville/Quonset Point, Rhode Island, or
- Port of Galilee, Rhode Island.

Since it cannot be known in advance where these vessels will ultimately originate from, and vessel route for all New York ports will generally be the same, as will the vessel routes for all Rhode Island ports, modeling of long-term transit emissions will use two possible route scenarios. These two transit scenarios will assume 100 percent of vessel traffic originates from both states, unless more information is learned about the Project's anticipated port usage between the protocol being approved and submission of the permit application. The annual transit modeling will run to and from the center of RWF and the outermost point of the OCS Permit area.

The preliminary locations of the sources for the two OCS Source O&M scenarios are provided in Appendix A. These layouts are representative of typical vessel locations, but it should be emphasized that these vessels will rarely be at the same location for each visit and is therefore a conservative simplification of actual vessel activity.

3.7 Receptor Locations

Receptor ring spacing will be 25 m out to 500 m, 250 m out to 1,000 m, 500 m our to 5,000 m, 2.5 km out to 10 km, and 5 km out to 50 km. Another ring of receptors will be placed every 1 degree at 50 km out, with additional receptors placed every 100 m over land to ensure complex terrain is captured. The total amount of receptors will vary depending on what point the ring originates from due to more receptors being needed overland, but each scenario will have no fewer than 1769 receptors.

For annual averaging periods, the center of the receptor grid will originate from the centroid of RWF and include a total of 2220 receptors. For short-term averaging periods, the point from which the receptors originate from will vary based on the scenario being modeled.

The center of the receptor grid for Scenarios 1, 2, and 3 will originate from the WTG location that is nearest to shore and have a total of 1937 receptors. The receptor grid for Scenario 5 will originate from the centroid and have a total of 2220 receptors, using the same receptor grid as the annual periods.

3.8 Modeling Constraints

The emissions sources being modeled are not stationary sources. They are the exhausts from vessels. Absent the unique requirements of 40 CFR Part 55, these sources would not be modeled (e.g., trucks delivering coal to a power plant would not be modeled).

The OCD model is designed to model stationary point sources. The model cannot address the fact that the vessel exhausts are moving up and down with the waves and forward with the vessel's motion. The line source option in OCD simply divides the line source into 10 point sources and OCD can only model one line source at a time, making that option impossible to use for this Project.

Similarly, the OCD model can only assess impacts at stationary receptors. Key receptors are entirely over water in locations where there cannot possibly be any residences, and where the public is unlikely to remain in one location for any extended period. The OCD model cannot address the fact that public receptors would need to be in vessels of their own, and those vessels would be in motion and so would not have a constant point of emissions.

Finally, the OCD model simply does not have tools to address the fact that not all NO_X emissions will be NO_2 subject to the NO_2 NAAQS. For example, there is no way to account for annual NO_X to NO_2 conversion using any of the EPA-approved methods.

As such, the modeling of moving vessels and the assessment of overwater receptors using the OCD model requires the use of more conservative assumptions than a traditional assessment of stationary sources on land.

3.9 Comparison to EPA Guidance

In Vineyard Wind's O&M Modeling Report, they presented justification for use of intermittent treatment of 1-hour NO_2 modeling of O&M activities. Given the similarities between these two Project's, their discussion has been included here, with adjustments as needed, to justify the intermittent treatment of 1-hour NO_2 modeling (VWF, 2018).

One key guidance document regarding modeling intermittent sources against probabilistic standards is EPA's March 1, 2011 memorandum, *Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour* NO_2 *National Ambient Air Quality Standard* (the Memorandum) (EPA, 2011). This section quotes relevant selections from the Memorandum and describes how they apply to the operation of the vessels performing regular (O&M) activities. The Memorandum is quoted in boxes below, followed by a discussion of relevance.

> *Modeling of intermittent emission units…has proven to be one of the main challenges for permit applicants undertaking a demonstration of compliance with the 1-hour NO_2 NAAQS…*

The O&M vessels are truly emitting at any one location only intermittently. For example, the CTV will only be at any particular WTG or OSS location for approximately 24 hours each year.

> *…by assuming continuous operation of intermittent emissions the modeled design value for the 1-hour NO_2 NAAQS effectively assumes that the intermittent emission scenario occurs on the specific hours of the specific days for each of the specific years of meteorological data included in the analysis which factor into the multiyear average of the 98th percentile of the annual distribution of daily maximum 1-hour values. The probability of the controlling emission episode occurring on this particular temporal schedule to determine the design value under the probabilistic standard is significantly smaller than the probability of occurrence under the deterministic standard; thereby increasing the likelihood that impact estimates based on assuming continuous emissions would significantly overestimate actual impacts for these sources.*

The changes that an O&M vessel would be operating at a specific location for each of the hours needed to have the same modeled impact as a continuous emissions source is vanishingly small. For the probabilistic one-hour standard, the chance that an O&M vessel would be operating at specific location for each of the specific hours needed to have the same modeled impact as a continuous source is exceedingly unlikely.

> *…we will consider it acceptable to limit the emission scenarios included in the modeling compliance demonstration for the 1-hour NO_2 NAAQS to those emissions that are continuous enough of frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations.*

At any one location, the O&M vessel emissions are not continuous enough or frequent enough to contribute significantly to an annual distribution of daily maximum 1-hour concentrations. By the reasoning in the Memorandum, excluding the O&M vessel emission from the 1-hour NO_2 modeling would be acceptable.

> *Additional discretion may need to be exercised in such cases to ensure that public health is protected. For example, an intermittent source that is permitted to operate up to 500 hours per year, but typically operates much less than 500 hours per year and on a random schedule that cannot be controlled would be appropriate to consider under this guidance. On the other hand, an 'intermittent" source that is permitted to operate only 365 hours per year but is operated as part of a process that typically occurs every day, would be less suitable for application of this guidance since the single hour of emissions from each day could contribute significantly to the modeled design value based on the annual distribution of daily maximum 1-hour concentrations.*

We note that extra efforts to protect public health are not warranted in this case. There are no members of the public residing 13 kilometers out at sea.

> *Another aspect of intermittent emissions worth noting is the distinction between intermittent emissions that can be scheduled with some degree of flexibility versus intermittent emissions that cannot be scheduled.*

While some of the O&M activities are "routine", the timing and order of the visits will not be in a set pattern, and the schedule will change regularly based on weather conditions.

> *Another approach that may be considered in cases where there is more uncertainty regarding the applicability of this guidance would be to model impacts from intermittent emissions based on an average hourly rate, rather than the maximum hourly emission. For example, if a proposed permit includes a limit of 500 hours/year or less for an emergency generator, a modeling analysis could be based on assuming continuous operation at the average hourly rate, i.e., the maximum hourly rate times 500/8760. This approach would account for potential worst-case meteorological conditions associated with emergency generator emissions by assuming continuous operation, while use of the average hourly emission represents a simple approach to account for the probability of the emergency generator actually operating for a given hour.*

Revolution Wind has followed this approach for each WTG or OSS location. For each WTG or OSS location, the O&M vessels were modeled based on the number of hours per year they would be emitting at that location, divided by 8,760. Per the above, this is a more conservative approach than excluding the O&M vessels from modeling against the 1-hour NO_2 NAAQS standard.

> *When EPA is the reviewing authority for a permit, for the reasons described above, we will consider it acceptable to limit the emission scenarios included in the modeling compliance demonstration for the 1-hour NO_2 NAAQS to those emissions that are continuous enough or frequent enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations. Consistent with this rationale, the language in Section 8.2.3.d of Appendix W states that "[i]t is appropriate to model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled." While we recognize that these intermittent emission sources <u>could</u> operate at the same time as the primary source(s), the discussion above highlights the additional level of conservatism in the modeled impacts inherent in an assumption that they do <u>in fact</u> operate simultaneously and continuously with the primary source(s).*

Since Revolution Wind's O&M activities are intermittent in nature, and the O&M activities of South Fork Wind will also be intermittent, Revolution Wind will not perform cumulative 1-hour NO_2 modeling.

3.10 Visibility

The Lye Brook Wilderness Area in Southern Vermont is the closest Class I area to RWF. Lye Brook is located approximately 252 km to the northwest of the Project. The Brigantine Wilderness Area in New Jersey is approximately 310 km to the southwest of the Project. The U.S. Forest Service (USFS) have requested that a Visibility analysis be performed for construction emissions using CALPUFF. A protocol for this analysis has been prepared for and approved by the USFS. Therefore, considering that the O&M emissions are only 5% of the construction emissions, the results of the construction phase Visibility modeling will imply compliance for the O&M emissions.

A visibility analysis will be conducted using the EPA VISCREEN model for Class II vistas at Block Island and Martha's Vineyard. The worst-case O&M annual emissions for NO_X and particulate matter will be used for the analysis.

A Level 1 screening in the VISCREEN model is designed to provide a conservative estimate of visual impacts from the emission plume(s). This conservatism is achieved by assuming worst-case meteorological conditions: extremely stable (F) atmospheric conditions, coupled with a very low wind speed (1 meter per second) persisting for 12 hours, with a wind that would transport the plume directly adjacent to the observer. The observer is located at the closest location of the Class II on-land areas (Block Island, Martha's Vineyard) to the proposed source per VISCREEN guidance.

3.11 Soils and Vegetation

PSD regulations require analysis of air quality impacts on sensitive vegetation types with significant commercial or recreational value or sensitive types of soil. Although the O&M activities are overwater and several miles from the nearest land area, an evaluation of impacts on sensitive vegetation will be performed by comparison of predicted Project impacts with screening levels presented in *A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils and Animals* (EPA, 1980) These procedures specify that predicted impact concentrations used for comparison account for project impacts and ambient background concentrations.

3.12 Growth

An analysis will be provided that assesses the impact of emissions from secondary growth during O&M. The analysis will qualitatively discuss the expected jobs, growth, expansion, and the possible impacts it may have on the local infrastructure and supply chains, and whether this secondary growth will cause significant impacts. This analysis will use data produced for Revolution Wind's Construction and Operations Plan.

4.0 REFERENCES

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Appendix A

Meteorological Data and Air Dispersion Modeling Comparisons

A.1 Meteorological data

Meteorological data for the air dispersion modeling were extracted from three consecutive years of WRF prognostic model data (2018-2020) obtained from EPA Region 1. EPA used the MMIF program to extract the necessary meteorological parameters at the points listed in Table A-1. MMIF converts prognostic meteorological model output fields to the parameters and file formats required for execute EPA's AERMET (overland) and AERCOARE (overwater) meteorological processors. MMIF extracts the appropriate data for geographical points by determining which grid cell a point lies within, and then extracting data from that cell. The WRF grid cells are spaced approximately 12 kilometers (km) [6 nautical miles (nm)] apart, center to center.

Table A-1 provides the geographical locations identified for the extraction, which represent the Weather Research and Forecasting (WRF) grid cell centers that were determined to be closest to the locations of observed (OBS) meteorological data. The "overwater extraction point for OCD modeling" and "Project centroid WRF grid point" corresponds to the Revolution Wind centroid and WRF extraction point for the overwater data to be used in the OCD modeling. Because Buzzards Bay buoy doesn't collect water temperature data, the centroid WRF data was also used to compare WRF water temperature to that collected by the Block Island Buoy (44097). The other points shown in the table correspond to the overwater and overland points used for the Buzzards Bay buoy (overwater) and KMVY (overland) extraction points for the remaining meteorological parameters. The overwater extraction point corresponds to the location of the Buzzards Bay Buoy, such that a comparison can be made with the wind data collected from buoy. The overland extraction point corresponds to the location of Martha's Vineyard Airport, which was identified as the nearest ASOS station to the Project. The OBS buoy data was obtained from NDBC's historical data.[3] The OBS overland data was obtained from NCDC's ftp site.[4]

Data for the overwater points were extracted by EPA using the AERCOARE and AERMET output option. The AERCOARE output provides essential parameters that are unique to overwater environments, but the wind data is limited to 10-m (meter) measurements. Although the AERMET output does not provide the essential overwater parameters provided by AERCOARE, the AERMET output provides more wind data at multiple heights. Since the overwater OBS wind data collected by the buoy is measured at a height of 30-m, to best match the OBS buoy data, the AERMET option was used to replace the 10-m wind speed and direction with 30-m winds. To produce SFC and PFL files, the AERCOARE outputs were processed using the AERCOARE meteorological data processer. The parameters that were input into AERCOARE included wind speed, wind direction, sea surface temperature, air temperature, relative humidity, pressure, longwave radiation, mixing height, and vertical potential temperature.

The overland points were extracted using the AERMET output, which extracts the parameters and files needed for to process the meteorological data through AERMET and produce SFC and PFL files.

Table A-1 WRF Extraction Points and Grid Point Locations

Description	Latitude (°)	Longitude (°)	Comment
Project centroid extraction point for OCD modeling	41.153	-71.073	Corresponds to Project centroid for OCD model overwater data and nearest to the Block Island Buoy.
Project centroid WRF grid point	41.193	-71.066	Center of grid point approximately 4 km [2 nm] NE of centroid and 26 km [14 nm] from Block Island buoy (44097.
Overwater extraction point	41.397	-71.033	Corresponds to approximate location of Buzzards Bay buoy.
Overwater WRF grid point	41.402	-70.985	Center of grid point approximately 4 km [2 nm] NE from buoy.
Overland extraction point	41.393	-70.615	Corresponds to approximate location of KMVY.
Overland WRF grid point	41.444	-70.667	Center of grid point approximately 7 km [4 nm] NW from KMVY.

[3] https://www.ndbc.noaa.gov/station_history.php?station=buzm3
[4] https://www1.ncdc.noaa.gov/pub/data/noaa/2020/

The Buzzards Bay buoy was chosen for the overwater observation data because it is located in proximity to the Project and within 50 km [27 nm] model domain. The buoy records hourly wind speed and wind direction data at a height of 24.8 m above sea level. Several months of data were missing from the 2019 data. Other buoys were considered for use in the met data comparison, but of the two others located within the OCD model domain, one does not measure wind data, and the other had more missing data. The Newport Station, NWPR1, was not considered for use in the comparison since the station is technically on land and would be a poor representation for overwater conditions Therefore, the Buzzard's Bay buoy was carried forward in the comparison. Block Island buoy was also selected for water temperature comparisons at the request of EPA Region 1.

KMVY was selected as the overland site for comparison to the extracted overland WRF data. This station is located 47 km [25 nm] northeast of the Project centroid and contained all parameters required to process an AERMET and AERMOD meteorological file. Wind data was 98 percent complete over the 3-year period.

A surface station located on Block Island was deemed unsuitable because it does not measure many of the parameters required for adequate AERMET processing. Other surface stations on eastern Long Island, Massachusetts, and Rhode Island were deemed too far away from the OCD model domain of 50 km [27 nm] to provide a useful comparison.

The OCD model requires, at minimum, the following overwater parameters:

1) Mixing height
2) Humidity
3) Ambient air temperature
4) Water surface temperature

The model also can accept wind direction and speed, wind shear, turbulence intensities, and temperature gradients, if available. Overland meteorological parameters required by the OCD model include the following:

1) Wind speed and direction
2) Ambient air temperature
3) Stability class
4) Rural mixing height

A.2 Comparison of Observed Data to Weather Research and Forecasting Data

Comparisons between OBS meteorological data and WRF data extracted from the WRF were performed, and the results are discussed in this section. Figures and tables associated with the data comparison assessment are also presented in this section. The comparisons were developed consistent with the EPA guidance document, *Evaluation of Prognostic Meteorological Data in AERMOD Applications* (EPA, 2018).

Comparisons were made between the overwater WRF and OBS data (2018 and 2020), and the overland WRF and OBS data (2018 – 2020). Where data was missing in the OBS data, the WRF data was replaced with missing values. The wind data used in the overwater WRF data was representative of 30-m heights from the AERMET MMIF output to better match with the overwater OBS data measured at 24.8 m. For the overland comparison, OBS meteorological data from KMVY was obtained, along with upper air data from Chatham Municipal Airport, Massachusetts. The OBS data were processed using AERSURFACE Version 13016 and AERMET Version 21112.

A.2.1 Wind Roses

Wind roses for the OBS and WRF meteorological data sets for the overwater location and the overland location are presented in Figures A-1a through A-1d. The 3-year wind rose for the OBS and WRF data for the KMVY location is provided on Figure A-1a. A comparison of seasonal wind roses for this location is provided in Figure A-1b. The overwater and overland wind roses both exhibit a strong component from the southwest for all cases, which is more pronounced in the summer months. In the winter, the frequency of winds from the northwest increases in both cases.

The overwater data comparison is provided in Figure A-1c (3-year wind rose) and Figure A-1d (seasonal wind roses). The same characteristics are shown for these data, with a prevailing southwesterly component for most all seasons except winter, when winds shift to the northwest.

Overall, the agreement between the WRF data and the Buzzards Bay buoy for the overwater location is very good, with both the direction and frequency of winds from various directions in agreement. Seasonal variability is also well reproduced by the WRF data. The WRF data used to develop these wind roses were from the 30-m level, while wind measurement from the buoy is from a height of 24.8 m. This slight difference in heights likely accounts for the slightly higher winds that can be seen in the WRF wind roses.

The good agreement between the wind direction and wind speed data as shown by the wind roses indicates that the WRF data set provides representative model results when used within the OCD model. A further discussion of how each of the meteorological data sets impacts air dispersion modeling results is provided in Section 4.0.

A2.2 Wind Displacement

The displacement comparison is a measure of the difference in the OBS and WRF data wind vectors on an hourly absolute value basis. Figure A-2 shows the distribution of displacements for each year of data (2018, 2019, 2020) for both overland and overwater. The box for each data comparison corresponds to the first and third quartile results (upper and lower limits of the box), along with the median (horizontal line through the center of the box) and average values ("x" within the box). The overwater WRF data used for this comparison are the 30-m winds which were in better agreement with the 24.8-m OBS winds than with the 10-m WRF winds.

The overland data comparison in general show better agreement than the overwater data. Median displacements for overland data are approximately 4 km [2 nm], whereas the median displacement for overwater is approximately 11 km [6 nm], which is likely due to the higher wind speeds at 30 m and 24.8 m. Small differences in wind direction at higher wind speeds creates a larger displacement than vectors with lower wind speeds.

A.2.3 Surface Roughness

Figures A-3a and A-3b show the variation in surface roughness as a function of direction for each season of the year for the WRF data and the OBS data from KMVY. The plots show the WRF data surface roughness estimates are higher than the surface roughness in the vicinity of the airport except for a few wind directions in spring, summer, and fall. The WRF data surface roughness is 0.44 m for the entire year and is isotropic. For most wind directions and seasons, the WRF surface roughness is higher than the surface roughness around KMVY by approximately a factor of 2. The surface roughness during the winter season presents the largest difference between the WRF-extracted surface roughness and the KMVY surface roughness.

In the OCD model, overwater observations of wind direction and wind speed are assumed to apply to both overwater and overland areas. If overwater meteorological observations are not available, then hourly overland values are used. If overwater measurements of wind direction and wind speed are available, as is the case for this proposed modeling study, then the only overland meteorological parameters used by the OCD model are overland stability class, temperature, and turbulence. Therefore, overestimation of overland surface roughness is not critical for the OCD model because it predominantly uses overwater parameters.

A.2.4 Comparison of Primary and Calculated Overland Meteorological Parameters

Table A-2 lists the statistics for several primary variables in the overland data, including wind speed, temperature, pressure, and relative humidity. The table also lists statistics for heat flux, surface friction velocity, Monin-Obukhov length, and cloud cover. These comparisons were done for all 3 years of OBS and WRF data from the KMVY location, as well as for all seasons individually, which can be seen in Tables A-3 through A-6. Finally, a comparison of the statistical parameters for a typical nighttime hour (3 a.m.) and a typical daytime hour (12 p.m.) is shown in Tables A-7 and A-8.

The equations used to calculate the mean bias and fractional bias are provided below. The mean and fractional bias result in a negative value when the WRF is underpredicted and a positive value when the WRF is overpredicted. Note that when using fractional bias for Monin-Obukhov length and heat flux, which have a range of positive and negative values, the fractional bias uses the absolute values of WRF and OBS data, meaning that the fractional bias may erroneously indicate a negative bias for these parameters even though the mean bias demonstrates a positive bias.

$$Mean\ Bias = \frac{1}{n}\sum_{1}^{n}(WRF - Observed)$$

$$Fractional\ Bias = \frac{2}{n}\sum_{i=1}^{n}\frac{(WRF_i - Observed_i)}{(WRF_i + Observed_i)}$$

Missing OBS data were not used in any of the statistical comparisons, and the corresponding hours from the WRF data were omitted. The findings from this statistical analysis include:

- There is a small negative mean bias in the wind speeds, meaning OBS wind speeds are slightly higher for the OBS data set than the WRF data set. Although wind speeds are slightly underpredicted by the WRF, the wind directions as shown in the wind roses are in good agreement. Agreement is highest in the winter and lowest in the spring.
- The WRF data tends to slightly overpredict temperature, pressure, humidity, and surface friction velocity compared to the OBS data set; however, the differences are minor. Agreement for temperature is highest in the winter and lowest in the summer. Agreement for pressure and surface friction velocity is highest in the summer and lowest in the winter. Agreement for humidity is highest in the summer and lowest in the spring.
- For heat flux, the WRF data overpredicts compared to the OBS data. Some of this disagreement is due to AERMET processing of heat flux, which often assigns a value of -64 to overnight hours, while WRF heat fluxes are typically greater than that value. Agreement is highest in the fall and lowest in the spring.
- Monin-Obukhov length differences show relatively low agreement between the two data sets. Monin-Obukhov lengths can be significantly different even within the same stability class. Within AERMET-processed data, this parameter varies from -8888 to 8888, and the fractional bias between the data sets decreases upon focusing on specific times of the day as seen in Tables A-7 and A-8. Agreement is highest in the fall and lowest in winter.
- Cloud cover differences also show relatively low agreement, but this may be due to the calculation that AERMET performs when cloud cover is missing. Agreement is highest in fall and lowest in winter.

Tables A-7 and A-8 show the statistical comparison for a typical daytime hour (12 PM) and a typical nighttime hour (3 AM), respectively. These comparisons were done by taking the data from these hours for every day of the data set. These specific hours were chosen to investigate possible diurnal variations in the selected parameters. For these times of day, wind speeds still show a negative bias like in the 3-year data. Looking at the remaining variables, the tables show that the 12 PM hour has slightly better agreement overall than the 3 AM hour, and both hours are similar to or an improvement from the 3-year averages in Table A-2. These tables show that agreement remains good for typical day and night hours.

A.2.5 Comparison of Primary and Calculated Overwater Meteorological Parameters

Table A-9 lists the statistics for the primary variables in the overwater data, including wind speed, temperature and pressure. These comparisons were done for all 3 years of OBS and WRF data from the Buzzards Bay buoy location, as well as for all seasons individually, which can be seen in Tables A-10 through A-13. Finally, a comparison of the statistical parameters for a typical nighttime hour (3 a.m.) and a typical daytime hour (12 p.m.) is shown in Tables A-14 and A-15.

Missing OBS data were not used in any of the statistical comparisons, and the corresponding hours from the WRF data were omitted. The findings from this statistical analysis include:

- There is a small positive mean bias in the wind speeds, meaning WRF wind speeds are slightly higher than the OBS data. Although wind speeds are slightly overpredicted by the WRF, the wind directions as shown in the wind roses are in good agreement. Agreement is highest in the spring and lowest in the fall.
- The WRF data tends to slightly overpredict temperature; however, the differences are minor. Agreement is highest in spring and lowest in the fall.
- The WRF data tends to slightly underpredict pressure; however, the differences are minor. Agreement is highest in the winter and lowest in the summer.

Tables A-14 and A-15 show the statistical comparison for a typical daytime hour (12 PM) and a typical nighttime hour (3 AM), respectively. These comparisons were done by taking the data from these hours for every day of the data set. These specific hours were chosen to investigate possible diurnal variations in the selected parameters. For these times of day, wind speeds show a negative bias, pressure shows a small negative bias, and temperature shows a positive bias at 12 PM and a negative bias at 3 AM. These tables show that agreement remains good for typical day and night hours.

Table A-16 presents the comparison between water temperature from the WRF grid near the centroid and the OBS data from Block Island Buoy. The water temperature indicates a small negative bias, meaning that the WRF underpredicts the water temperature compared to the OBS data, except in the spring when there is a small positive bias. Agreement is highest in summer and lowest in winter.

In summary, while there are differences between the WRF and OBS data, the WRF data appear to show good agreement with the OBS data for the annual, seasonal and diurnal comparisons. Wind roses for the overland and overwater data are in good agreement. The similarities between the two data sets in the various primary and calculated meteorological parameters imply that using the WRF data is appropriate for this dispersion modeling study and should provide reliable results. To verify suitability of the WRF data, air dispersion modeling was performed using the WRF and OBS data for both the overland and overwater sites.

A.3 Comparison of Dispersion Modeling Using Observed and Weather Research and Forecasting Meteorological Data

AERMOD was used to compare the results of air dispersion modeling using both the WRF and OBS meteorological data at two locations:

1) The overland location corresponding to the KMVY meteorological station, and
2) A location near the Buzzards Bay buoy but located on land at the Southwestern tip of Cuttyhunk Island; this on-land location was chosen so that AERMOD was still suitable as the dispersion model for the analysis.

Because the main purpose of the AERMOD modeling study is to compare the impacts of using the two different data sets at the two different locations, a single point source with a 20-m [65-ft] release height was used, and receptors were assigned at 200-m spacing of a 10-km by 10-km domain. Emissions were assumed at 1 gram per second and an arbitrary stack diameter of 0.5-m was assigned to the point source.

The OBS overland meteorological data used surface observations from KMVY and upper air data from Chatham, Massachusetts for years 2018 through 2020. The WRF data were extracted from the points indicated in Table A-1.

The overwater WRF data were extracted from the point indicated in Table A-1 corresponding to the Buzzard’s Bay buoy with speed and wind direction from a height of 30 m. For the OBS data set, because there are few parameters measured by the Buzzard’s Bay buoy, and there are no surface stations near Cuttyhunk Island, data from KMVY was used with wind speed and wind direction from the Buzzards Bay buoy. This is a reasonable approach because wind speed and wind direction are important parameters in a dispersion modeling impact assessment.

The OBS meteorological data was processed using AERMET, and surface characteristics at KMVY were determined via AERSURFACE.

A.3.1 Overland Modeling Results

The comparisons of model results are shown in Figures A-5 to A-6. The comparison considered 1-hour and 24-hour average concentrations. For the comparison, the highest 2,600 1-hour and 24-hour concentrations calculated over the 3 years over the entire receptor grid were sorted high to low for the model run using the WRF data and the model run using the OBS data. These data points were then plotted as shown in Figures A-5 and A-6. The WRF data concentrations are along the y-axis, and the OBS data concentrations are along the x-axis. The comparison of 1-hour results shows very good agreement at the low end of the graph with WRF data resulting in a slight overprediction at higher values. The 24-hour averages have even better agreement, with the data closely following the "WRF=OBS" trend line, with the WRF data slightly overpredicting at the higher concentrations. Overall agreement between the overland data is excellent.

The screening results are shown in Figures A-7 and A-8 for the 1-hour and 24-hour results, respectively. These figures show the average mean bias and standard deviation bias for the two data sets. The 1-hour results show that the standard deviation of the two data sets is very similar, but there is a positive bias, meaning that the WRF data are overpredicting the OBS data when averaged over all of the top 2,600 receptors. The 24-hour comparison in Figure A-8 shows excellent agreement of standard deviation and bias average. The bias average is positive, and the standard deviation is slightly above 0, meaning that the WRF data are overpredicting the OBS data when averaged over all of the highest 2,600 receptors. The 1-hour and 24-hour points are both within the 0.67 box, indicating excellent agreement.

Figures A-9 and A-10 show the distribution of fractional bias between the two data sets. The horizontal lines shown indicate the 95^{th}, 50^{th}, mean and 5^{th} percentiles as shown in the legend. The 1-hour results again show a positive bias, with most of the 2,600 data points having a fractional bias better than 0.09. The 24-hour results again show a positive bias, with most of the 2,600 data points having a fractional bias better than 0.3.

The results demonstrate excellent agreement between the WRF and OBS overland data, with a potential for overprediction by the WRF.

A.3.2 Overwater Modeling Results

The comparison of model results are shown on Figures A-11 to A-12. The comparison considered 1-hour and 24-hour average concentrations. For the comparison, the highest 2,600 1-hour and 24-hour concentrations calculated over the 2 years over the entire receptor grid were sorted high to low for the model run using the WRF data and the model run using the OBS data. These data points were then plotted as shown in Figures A-11 and A-12. The WRF data concentrations are along the y-axis, and the OBS data concentrations are along the x-axis. The comparison of 1-hour results shows good agreement at the very high end and very low end of the graph with WRF data resulting in a slight overprediction at mid-range values. The 24-hour averages in Figure A-12 indicate a slight underprediction at high end values, which are well above the "WRF = 0.5 x OBS" trendline. At lower end values, an overprediction is occurring that is sometimes as much as 2 x the OBS values.

The screening results are shown in Figures A-13 and A-14 for the 1-hour and 24-hour results, respectively. These figures show the average mean bias and standard deviation bias for the two data sets. The 1-hour results show good agreement and that the standard deviation of the two data sets have a small positive bias, meaning that the WRF data are slightly overpredicting the OBS data when averaged over all of the top 2,600 receptors. The 24-hour comparison in Figure A-14 shows good agreement of standard deviation and bias average. The bias average is positive, and the standard deviation is slightly above 0, meaning that the WRF data are overpredicting the OBS data when averaged over all of the highest 2,600 receptors. The 1-hour and 24-hour points are both within the 0.67 box, indicating good agreement.

Figures A-15 and A-16 show the distribution of fractional bias between the two data sets. The horizontal lines shown indicate the 95^{th}, 50^{th}, mean and 5^{th} percentiles as shown in the legend. The 1-hour results again show a positive bias, with most of the 2,600 data points having a fractional bias better than 0.2. The 24-hour results show a more amplified positive bias, with most of the 2,600 data points having a fractional bias better than 0.58.

The results demonstrate good agreement in the WRF and OBS overwater data, with a potential for overprediction by the WRF.

A.3.3 Discussion of Modeling Results Comparison

Two meteorological data sets were prepared using surface observations from two locations, KMVY (the overland data set) and the other from Buzzards Bay buoy (the overwater data set). Upper air data from Chatham, Massachusetts were used along with the KMVY data and were processed using AERMET version 21112. This data set constituted the OBS overland data set. The OBS overwater data set was then developed by substituting the wind speed and wind direction from the overland data set with the wind data from the Buzzards Bay buoy. All other parameters were kept the same.

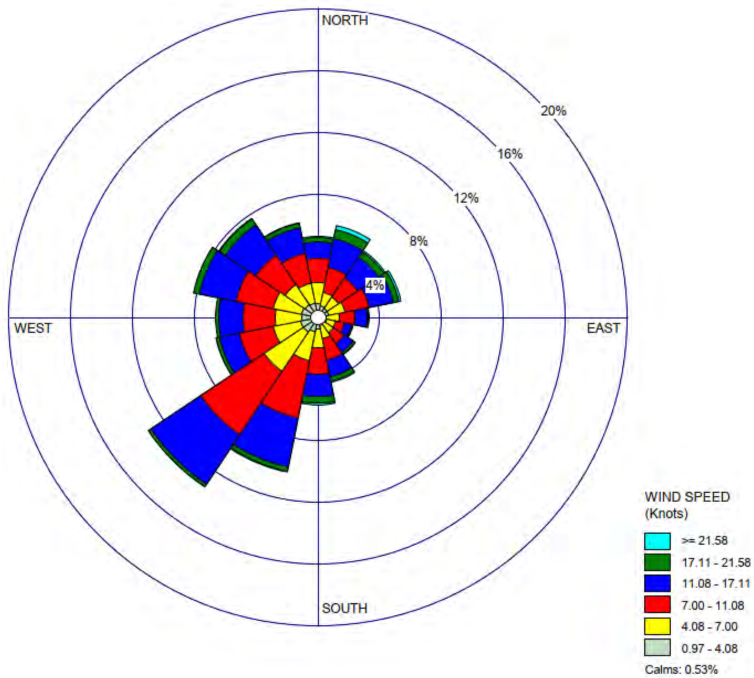
Two additional data sets were extracted from the 2018 through 2020 WRF data set for two locations consistent with Buzzards Bay and KMVY. These data sets constituted the overwater and overland WRF data sets, respectively.

The two overland meteorological data sets were then used to perform AERMOD runs for a single point source with unit emissions situated at the KMVY monitoring location. The two overwater data sets were used to perform AERMOD runs for a single point source at a location on the southwestern tip of Cuttyhunk Island. 1-hour and 24-hour averages were then sorted from high to low over the entire receptor grid and 3-year run (2-year for overwater), and these data were compared, as discussed.

The results show that there is good agreement between the meteorological data sets for both averaging periods with the paired points lying within the 2x lines on Figures A-5, A-6, A-11 and A-12 at the high end of the concentrations. However, there is an overall slight positive bias for both averaging periods and locations, meaning that the model results using the WRF data set were overpredicting, on average, those from the OBS data set. Therefore, although there is some variability at the high end of the predicted concentrations, in general, using the WRF data within the OCD model should similarly lead to conservative estimates of results compared to model runs using OBS data.

Although this comparison uses the AERMOD model and OCS air permit modeling uses the OCD model, this analysis is robust because it examines the impact that different meteorology alone will have on model-predicted results from a point source, and the conclusions are applicable to either model.

OBS KMVY



WRF – Near KMVY

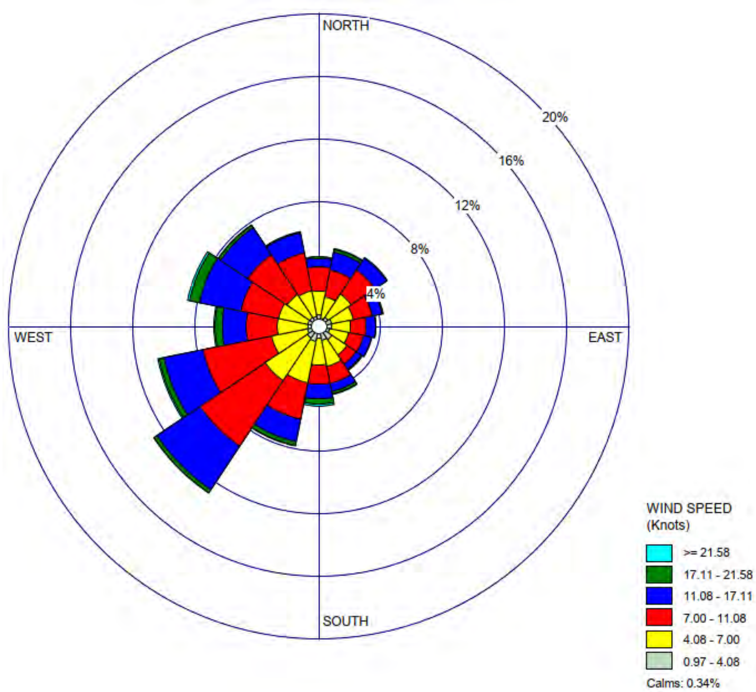


Figure A-1a. Wind Rose for Overland Data – OBS and WRF (2018-2020)

Spring: OBS KMVY WRF – Near KMVY

Summer:

Fall:

Winter:

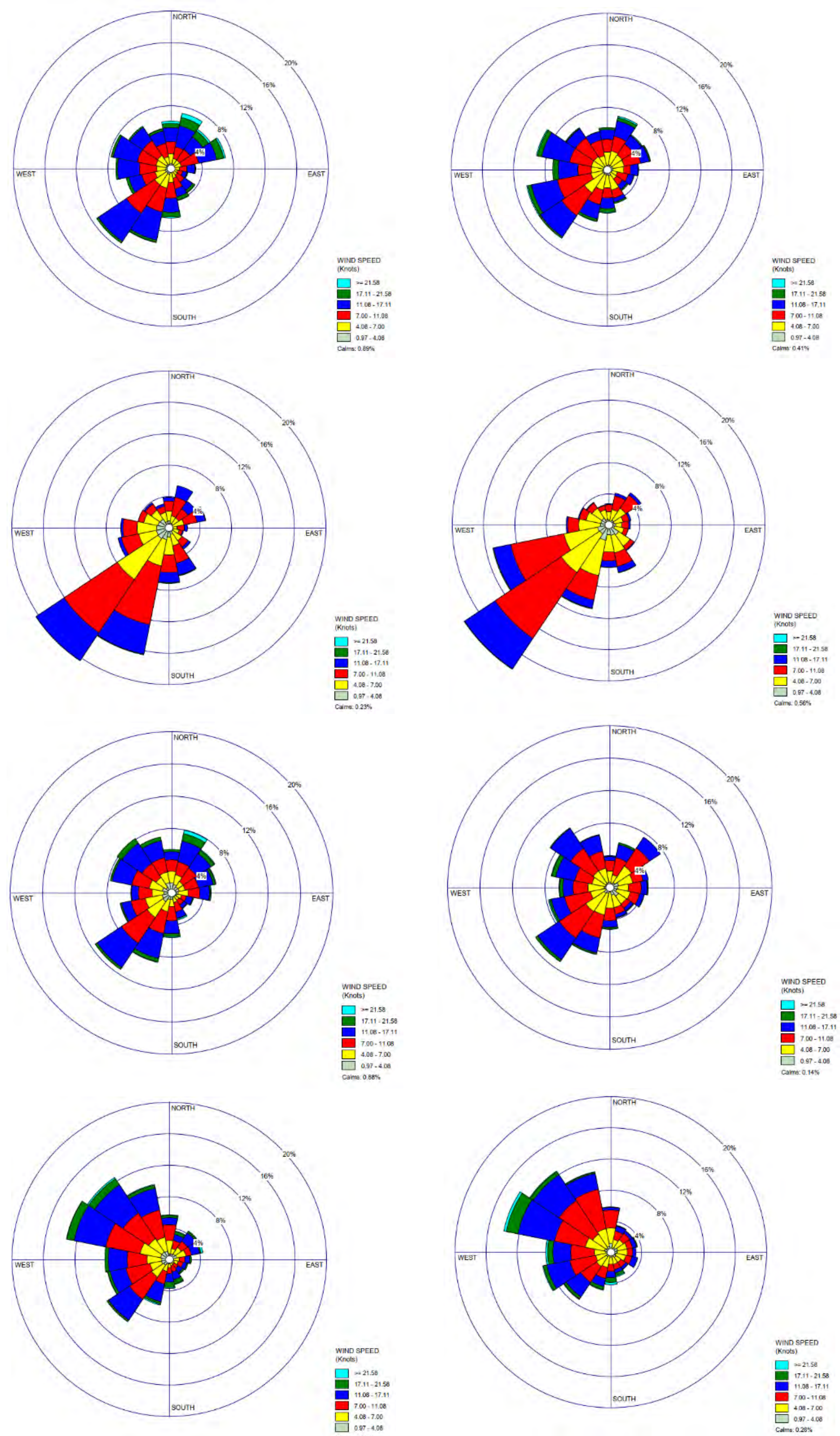
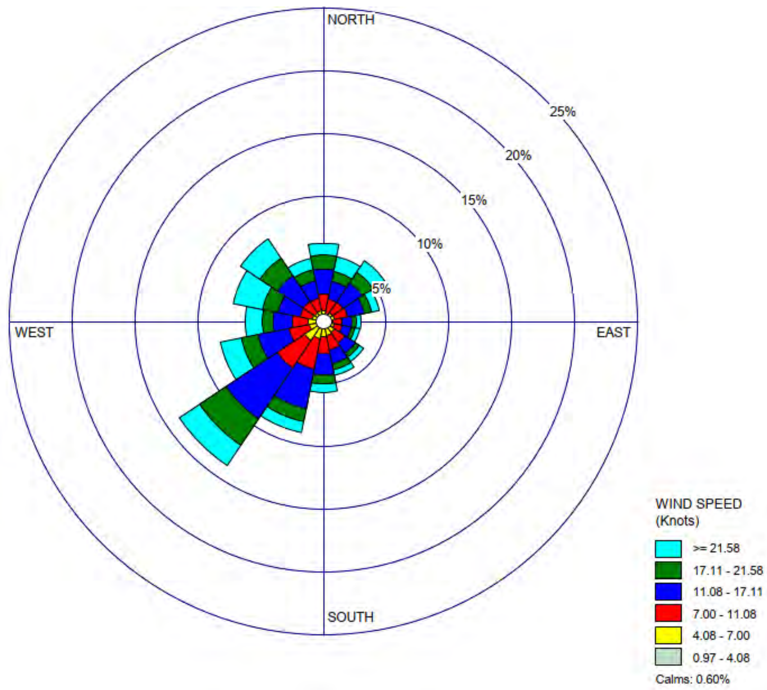


Figure A-1b. Seasonal Wind Rose for Overland Data – OBS and WRF (2018 – 2020)

OBS Buzzards Bay



WRF – Near Buzzards Bay

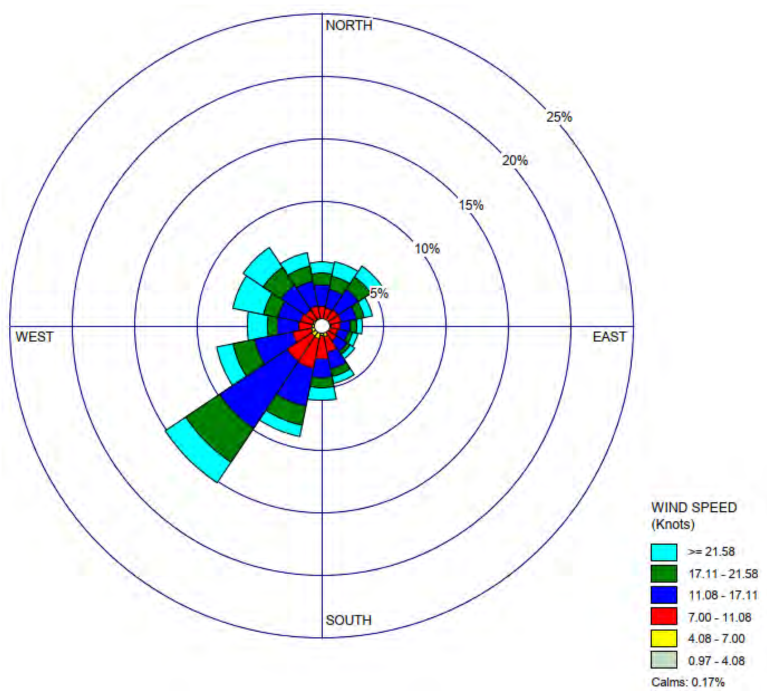
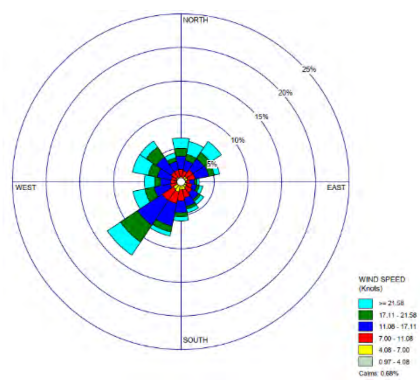
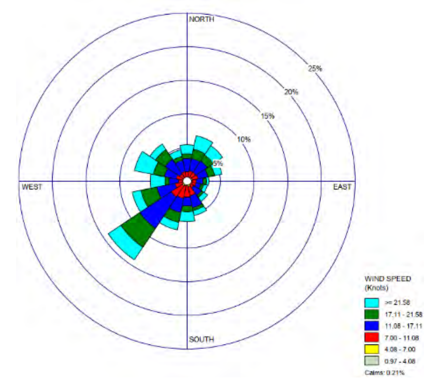


Figure A-1c. Wind Rose for Overwater Data – OBS and WRF (2018-2020)

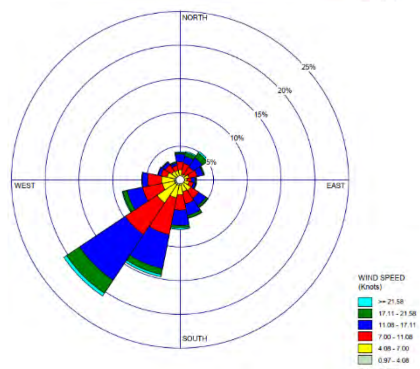
	OBS Buzzards Bay	WRF – Near Buzzards Bay

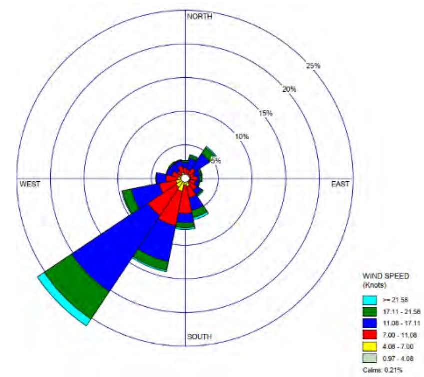
Spring:



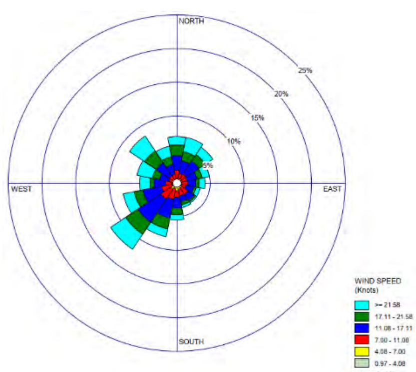


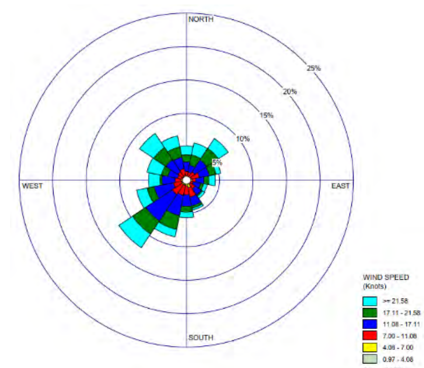
Summer:



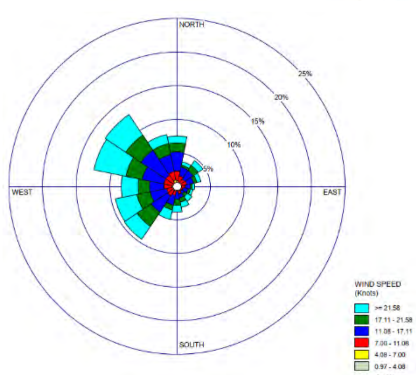


Fall:





Winter:



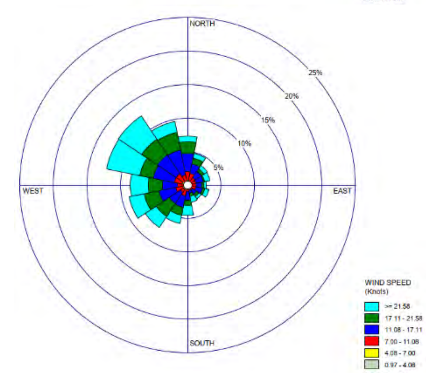


Figure A-1d. Seasonal Wind Rose for Overwater Data – OBS and WRF (2018 – 2020)

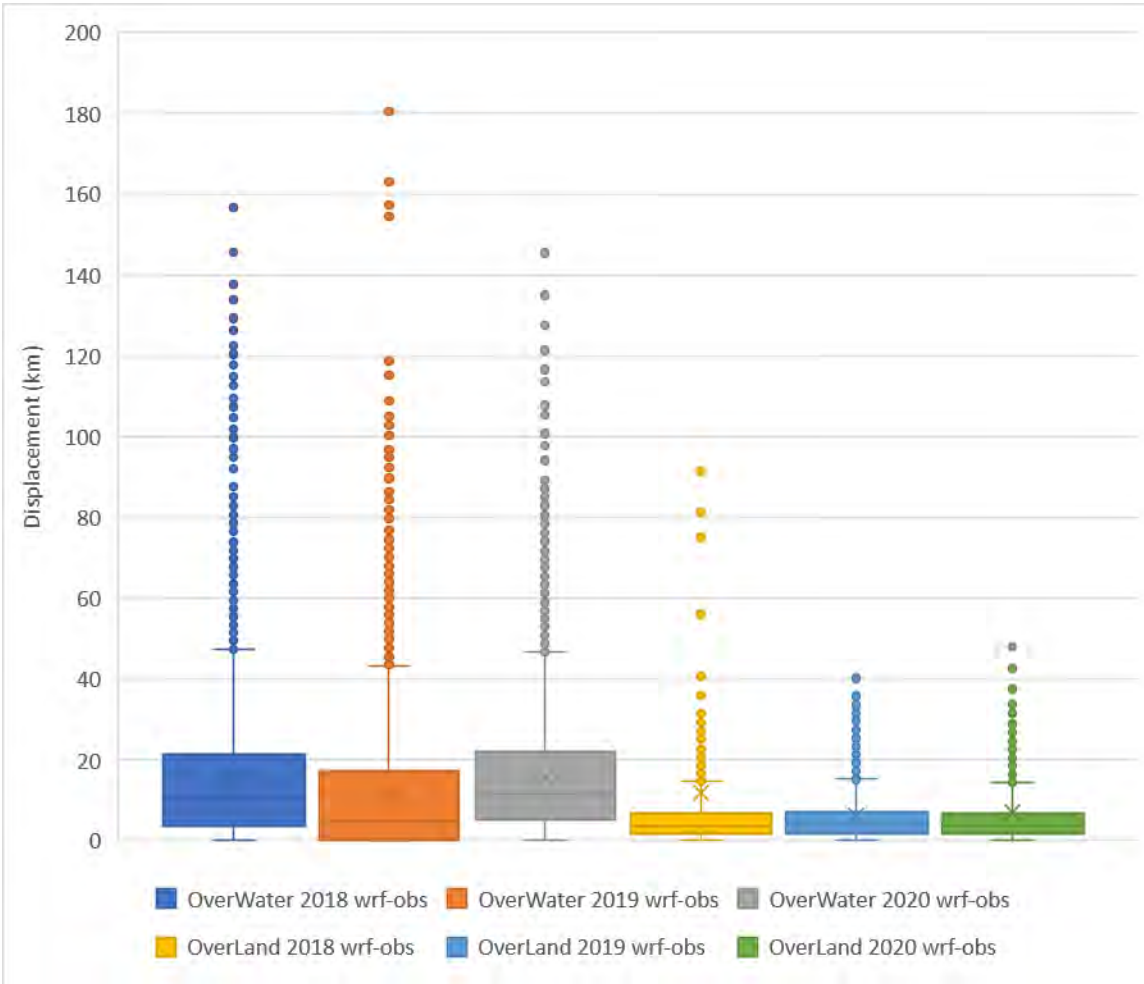
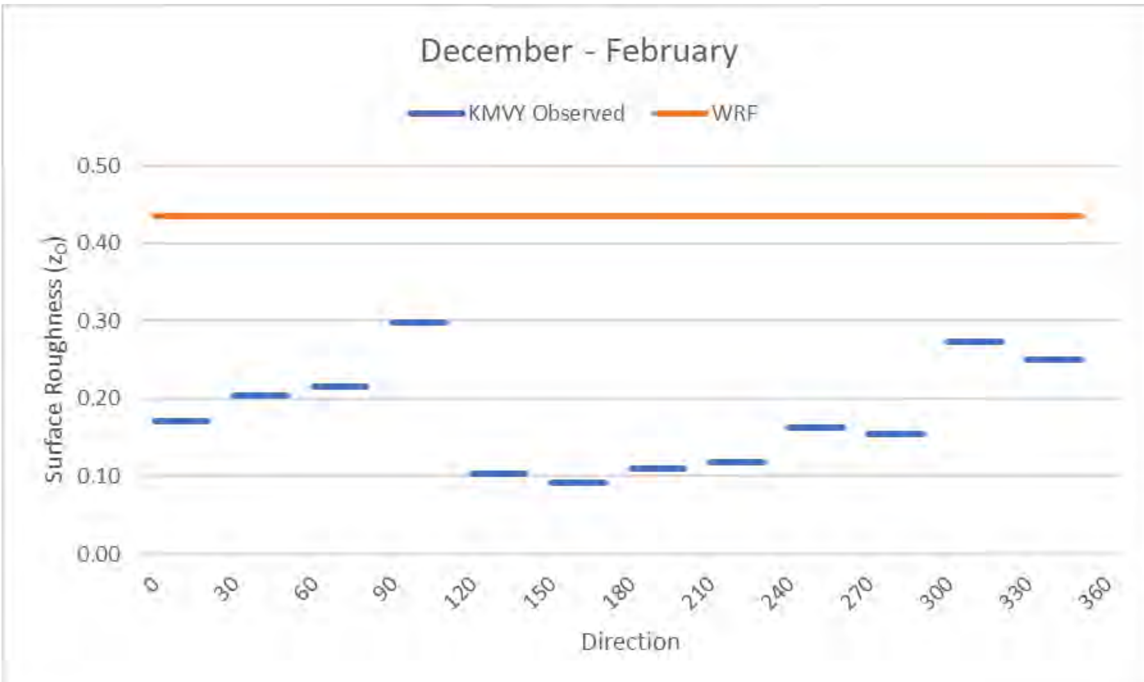


Figure A-2. Wind Displacement (km) for Overland and Overwater Data



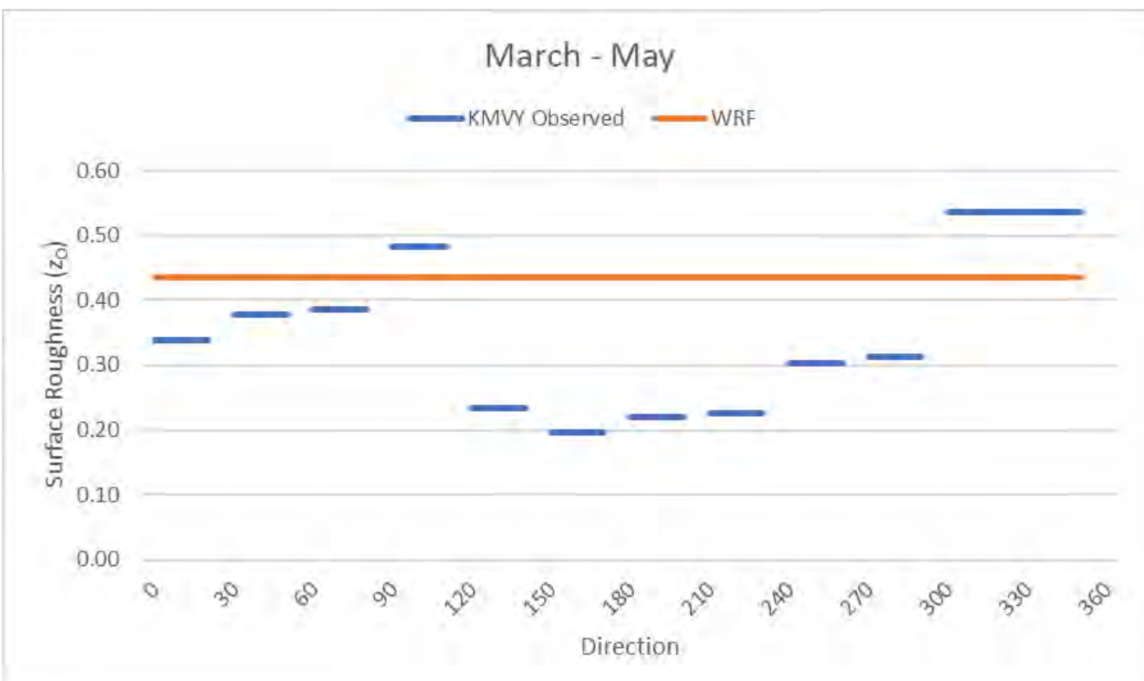
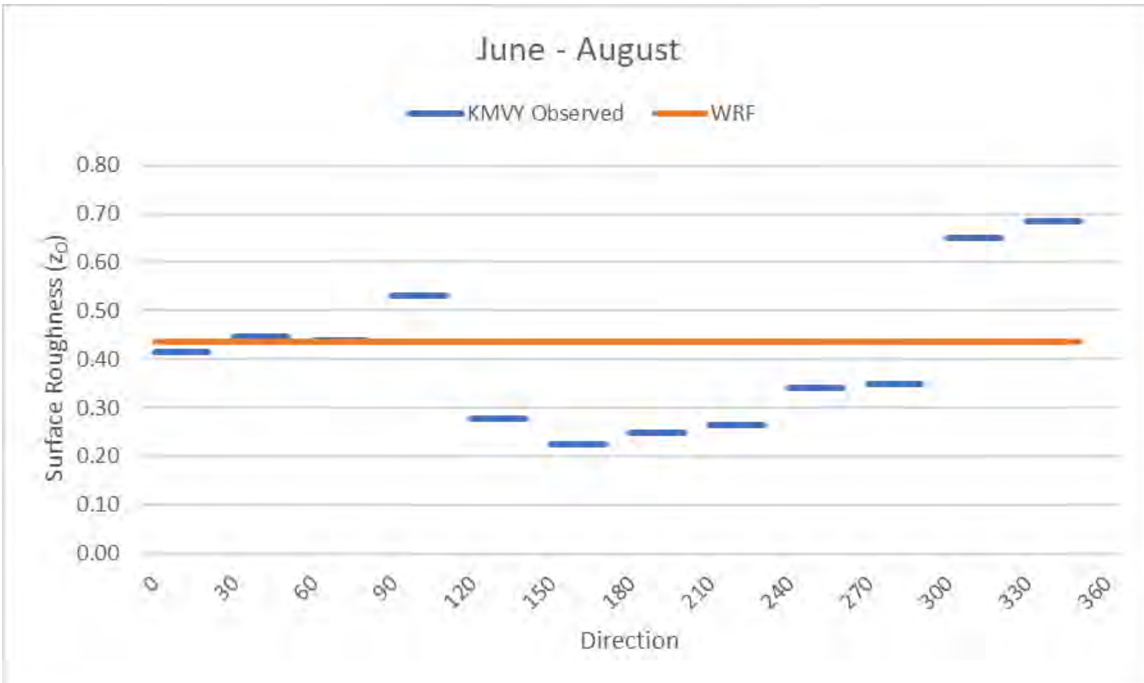


Figure A-3a. Surface Roughness by Wind Direction Sectors for Winter and Spring



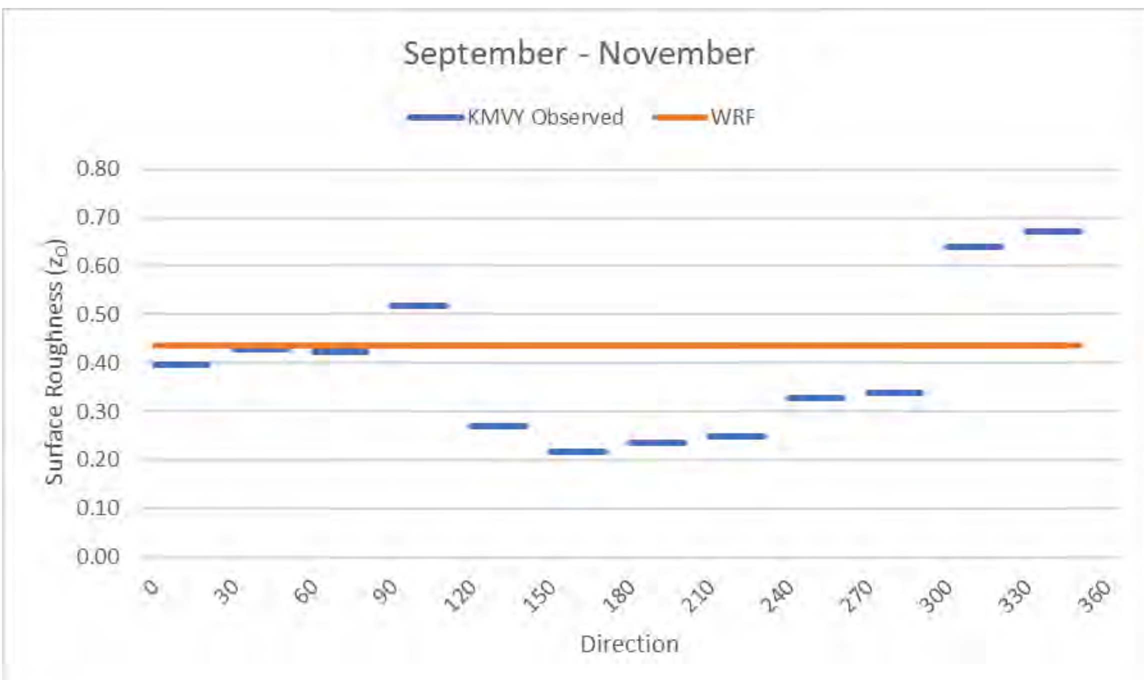


Figure A-3b. Surface Roughness by Wind Direction Sectors for Summer and Spring

Table A-2. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.368	-0.055	1.324	0.724
Temperature	0.478	0.002	1.946	0.955
Pressure	1.976	0.002	2.303	0.981
Relative Humidity	2.268	0.029	9.912	0.754
Heat Flux	29.659	-0.176	64.941	0.682
Surface Friction Velocity	0.013	0.029	0.195	0.609
Monin-Obukhov Length	286.138	-0.071	2325.019	0.067
Cloud Cover	1.667	0.746	4.882	0.209

Table A-3. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 Spring)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.564	-0.093	1.519	0.697
Temperature	0.293	0.001	1.731	0.912
Pressure	2.043	0.002	2.508	0.973
Relative Humidity	5.094	0.069	11.970	0.733
Heat Flux	49.212	-0.220	92.206	0.733
Surface Friction Velocity	-0.015	-0.026	0.196	0.631
Monin-Obukhov Length	413.620	-0.196	2021.963	0.116
Cloud Cover	1.515	0.746	4.576	0.277

Table A-4. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 Summer)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.281	-0.060	1.078	0.668
Temperature	0.945	0.003	1.948	0.862
Pressure	1.657	0.002	1.754	0.989
Relative Humidity	-0.978	-0.020	8.379	0.780
Heat Flux	28.127	-0.164	52.825	0.805
Surface Friction Velocity	0.004	0.003	0.148	0.593
Monin-Obukhov Length	127.678	-0.118	2802.565	0.021
Cloud Cover	1.775	0.788	4.739	0.230

Table A-5. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 Fall)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.406	-0.035	1.364	0.735
Temperature	0.547	0.002	2.182	0.901
Pressure	1.850	0.002	2.116	0.983
Relative Humidity	2.009	0.029	9.355	0.756
Heat Flux	7.959	-0.313	35.949	0.749
Surface Friction Velocity	-0.050	-0.056	0.209	0.651
Monin-Obukhov Length	137.122	-0.079	1314.342	0.341
Cloud Cover	1.430	0.634	4.798	0.208

Table A-6. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 Winter)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.219	-0.029	1.298	0.745
Temperature	0.063	0.000	1.878	0.883
Pressure	2.359	0.002	2.720	0.984
Relative Humidity	3.225	0.042	9.664	0.786
Heat Flux	34.632	0.012	67.007	0.545
Surface Friction Velocity	0.127	0.217	0.222	0.689
Monin-Obukhov Length	526.325	0.135	2877.224	0.026
Cloud Cover	1.950	0.814	5.385	0.131

Table A-7. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 12 PM)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.686	-0.158	1.421	0.700
Temperature	0.448	0.002	1.616	0.973
Pressure	1.954	0.002	2.211	0.985
Relative Humidity	-0.336	-0.013	10.890	0.713
Heat Flux	73.867	0.417	121.481	0.275
Surface Friction Velocity	0.018	0.007	0.186	0.551
Monin-Obukhov Length	283.023	-0.524	1118.070	0.156
Cloud Cover	-0.408	-0.216	3.664	0.430

Table A-8. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overland Meteorological Variables (WRF-OBS) (2018-2020 3 AM)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.185	-0.027	1.286	0.736
Temperature	0.911	0.003	2.594	0.918
Pressure	2.130	0.002	2.494	0.977
Relative Humidity	3.148	0.026	8.912	0.717
Heat Flux	13.646	-0.198	29.581	0.041
Surface Friction Velocity	0.002	0.036	0.201	0.611
Monin-Obukhov Length	302.043	-0.051	1167.193	0.208
Cloud Cover	1.910	0.709	5.079	0.174

Table A-9. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF-BUZM3) (2018-2020)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	0.137	0.030	3.012	0.491
Temperature	0.424	0.002	2.235	0.925
Pressure	-0.394	0.000	3.437	0.857

Table A-10. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 Spring)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	0.103	0.027	2.991	0.509
Temperature	0.121	0.000	1.753	0.877
Pressure	-0.426	0.000	3.022	0.896

Table A-11. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 Summer)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	0.087	0.029	2.464	0.314
Temperature	0.463	0.002	1.486	0.789
Pressure	-0.875	-0.001	2.065	0.891

Table A-12. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 Fall)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	0.159	0.036	2.923	0.530
Temperature	0.718	0.003	2.059	0.897
Pressure	-0.546	-0.001	3.264	0.844

Table A-13. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 Winter)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	0.171	0.026	3.398	0.422
Temperature	0.309	0.001	2.731	0.697
Pressure	0.081	0.000	4.448	0.833

Table A-14. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 12 PM)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.045	-0.003	3.143	0.465
Temperature	1.499	0.005	2.372	0.951
Pressure	-1.253	-0.001	3.244	0.893

Table A-15. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Select Overwater Meteorological Variables (WRF- BUZM3) (2018-2020 3 AM)

Variable	Mean Bias	Fractional Bias	RMSE	R^2
Wind Speed	-0.059	-0.006	2.962	0.492
Temperature	-0.273	-0.001	2.221	0.926
Pressure	-0.746	-0.001	3.472	0.852

Table A-16. Mean Bias, Fractional Bias, Root Mean Square Error, and R^2 for Water Temperature (WRF- Block Island 44097) (2018-2020)

	Mean Bias	Fractional Bias	RMSE	R^2
All	-0.253	-0.001	0.858	0.983
Winter	-0.720	-0.003	0.957	0.943
Spring	0.081	0.000	0.671	0.953
Summer	-0.004	0.000	1.017	0.920
Fall	-0.381	-0.001	0.737	0.950
12 PM	-0.117	0.000	0.856	0.982
3 AM	-0.240	-0.001	0.827	0.984

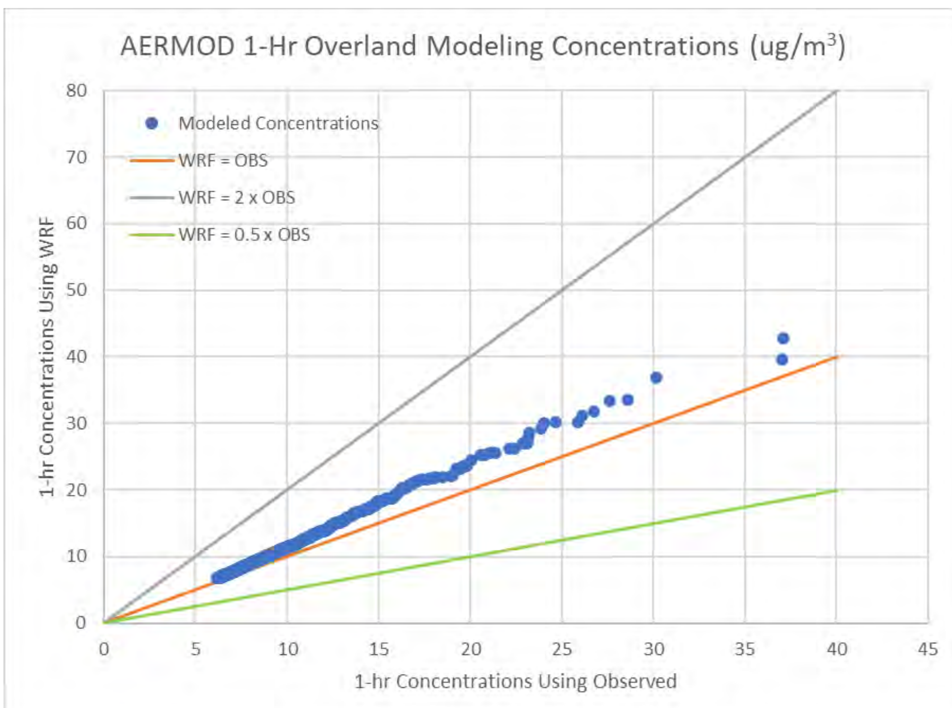


Figure A-5. Overland Quantile: Quantile Plot for 1-hour Averages

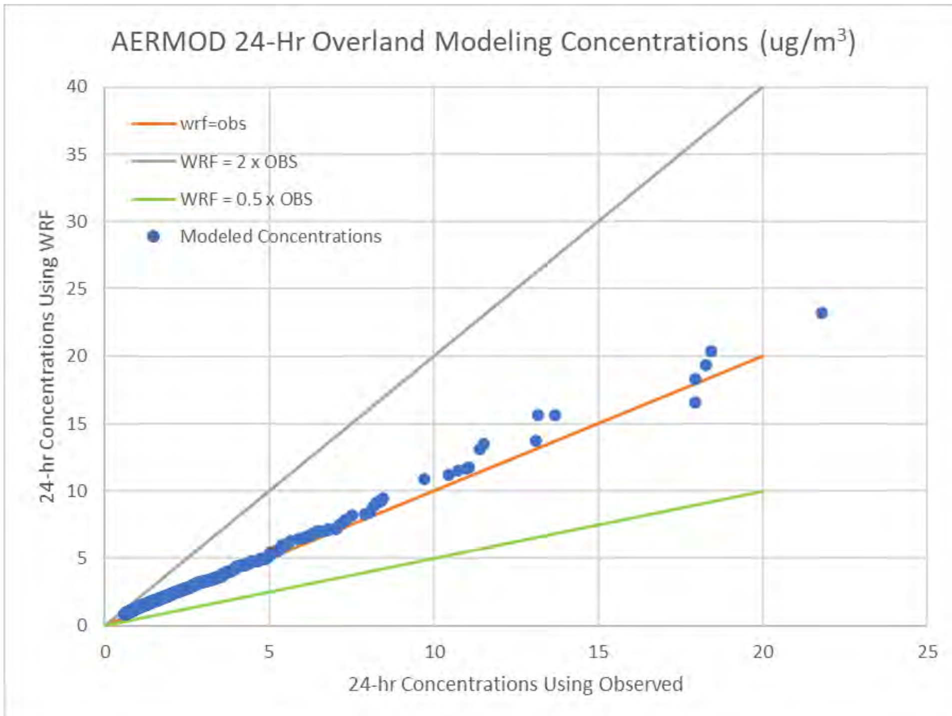


Figure A-6. Overland Quantile: Quantile Plot for 24-hour Averages

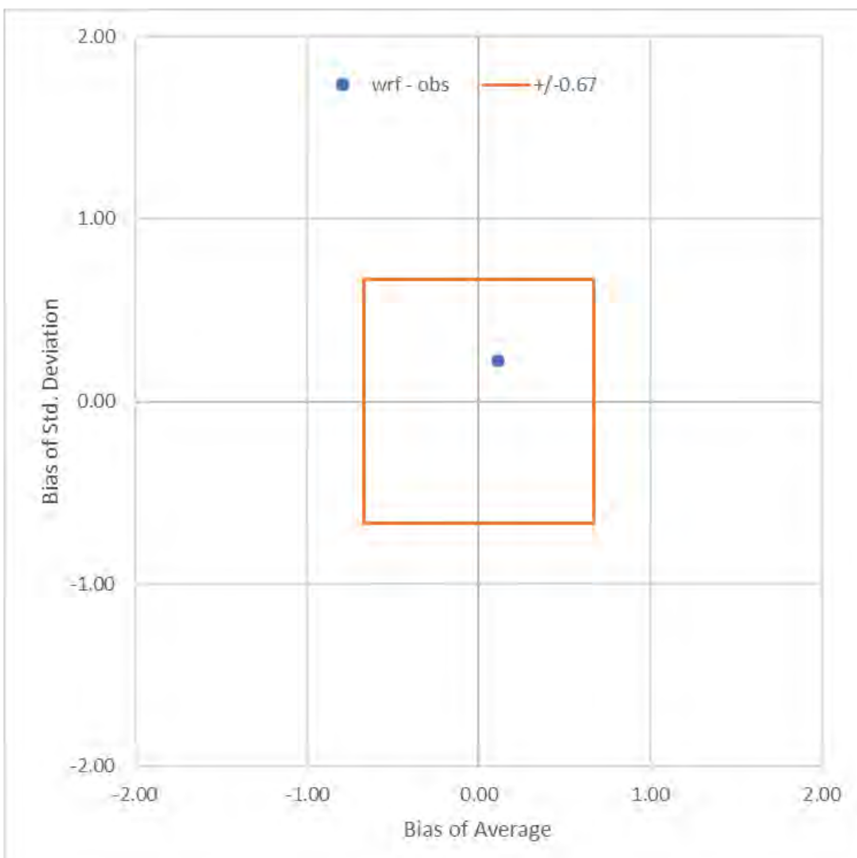


Figure A-7. Overland 1-hour Average Screening Results

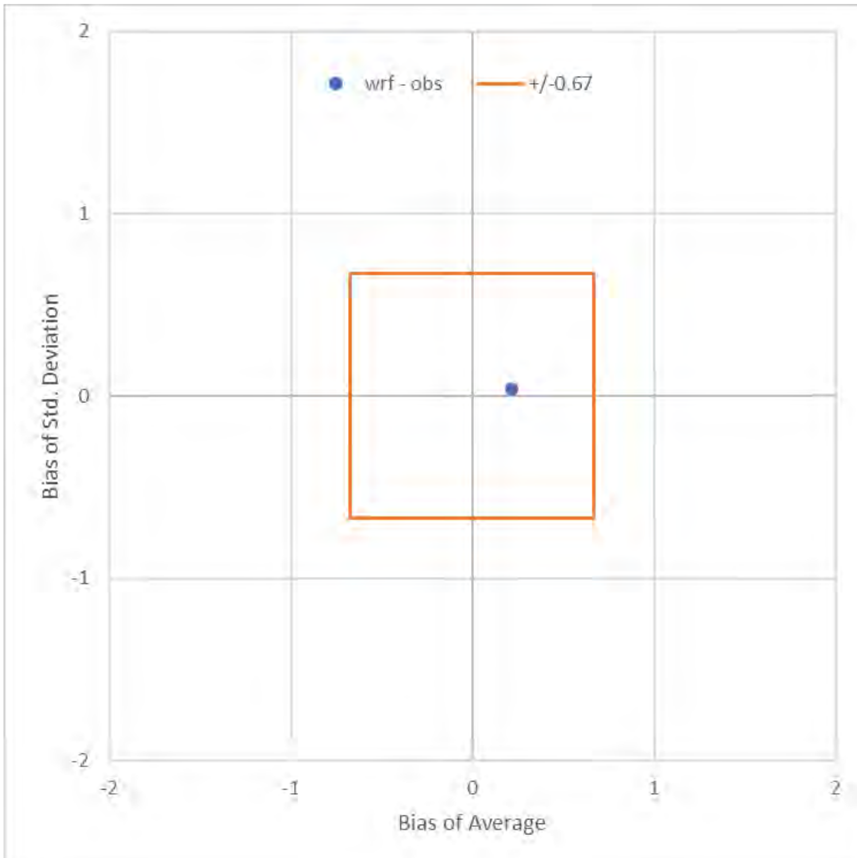


Figure A-8. Overland 24-hour Average Screening Results

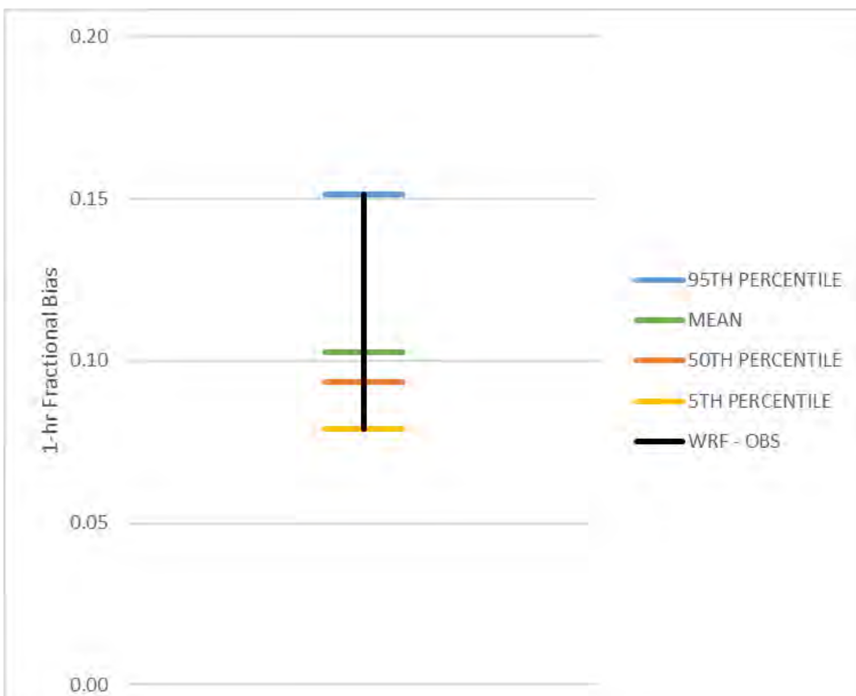


Figure A-9. Fractional Biases for Overland 1-hour Average Concentrations

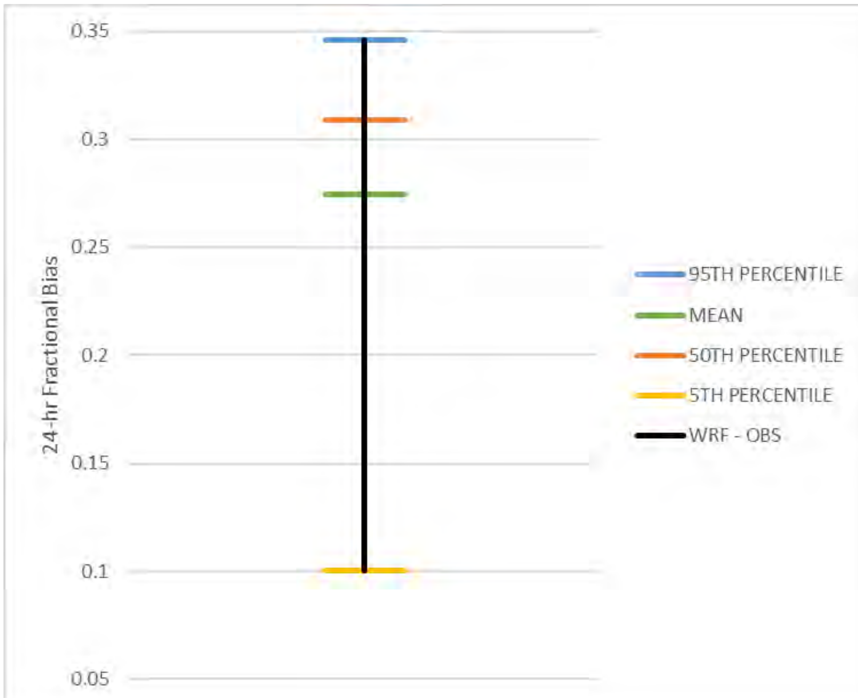


Figure A-10. Fractional Biases for Overland 24-hour Average Concentrations

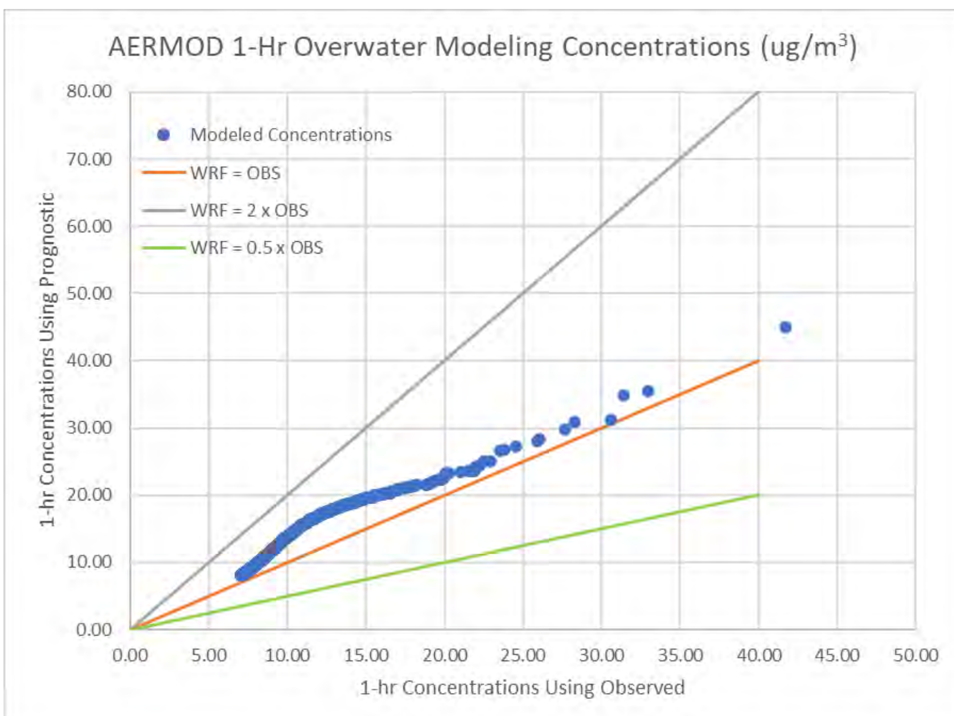


Figure A-11. Overwater Quantile: Quantile Plot for 1-hour Averages

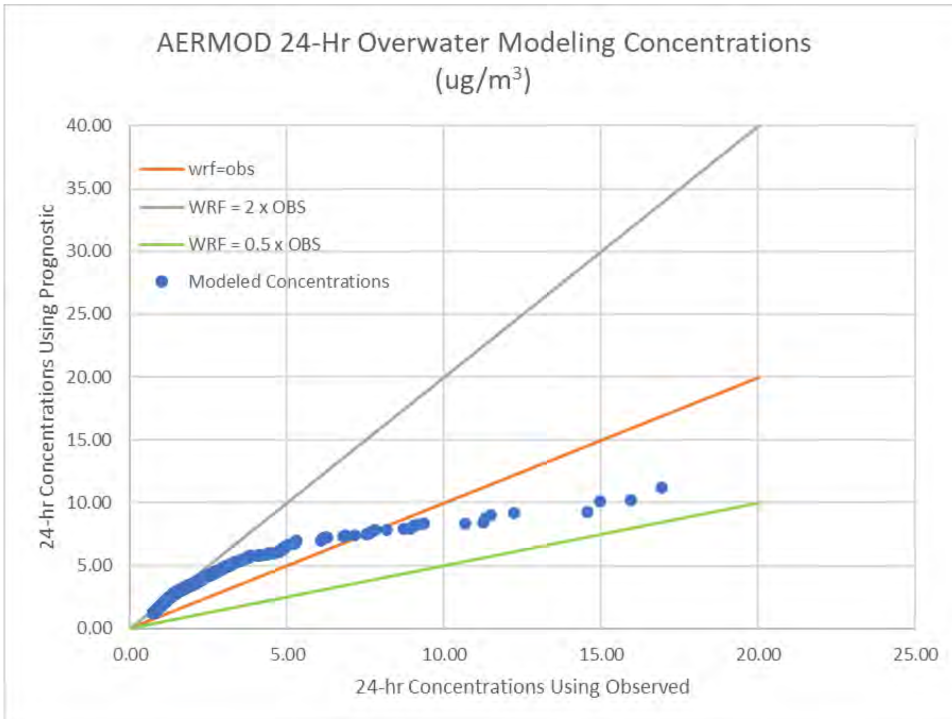


Figure A-12. Overwater Quantile: Quantile Plot for 24-hour Averages

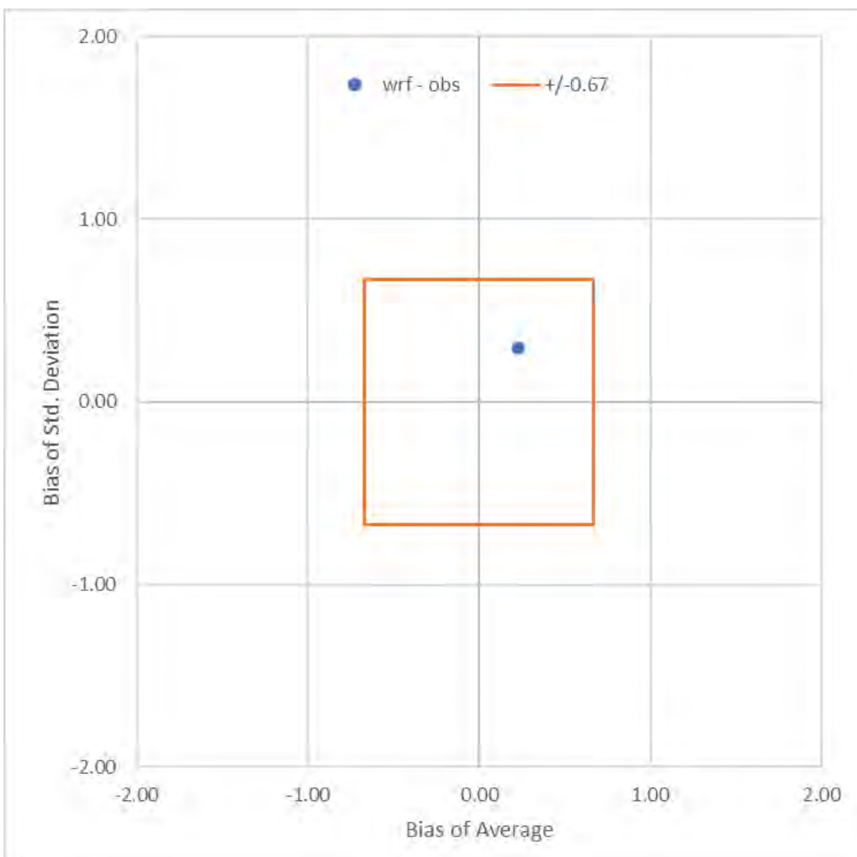


Figure A-13. Overwater 1-hour Average Screening Results

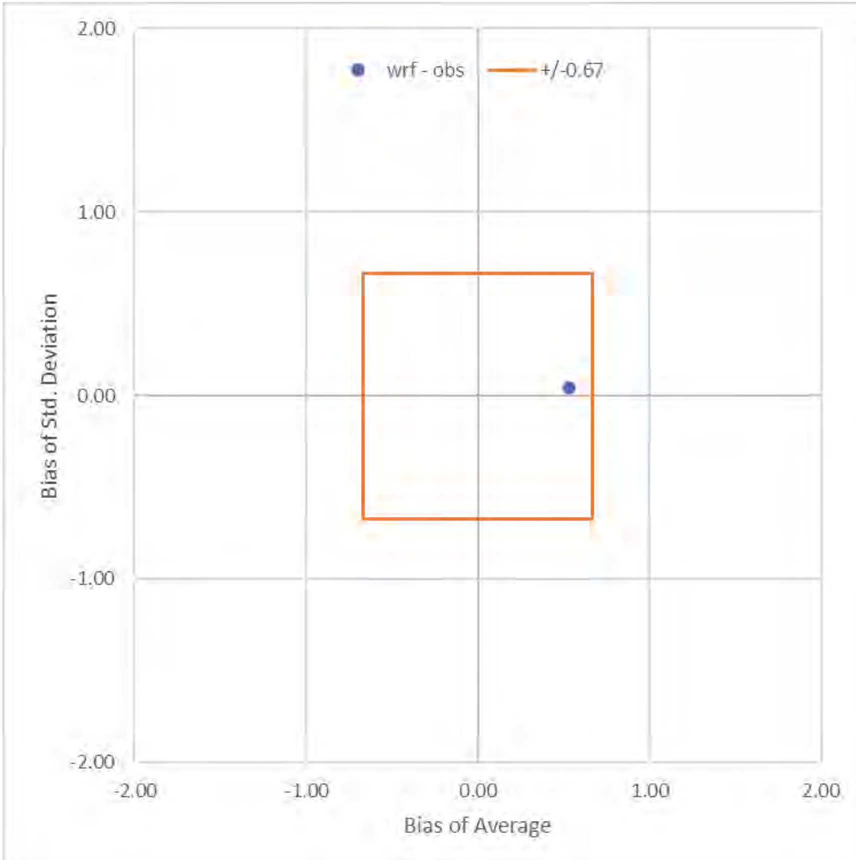


Figure A-14. Overwater 24-hour Average Screening Results

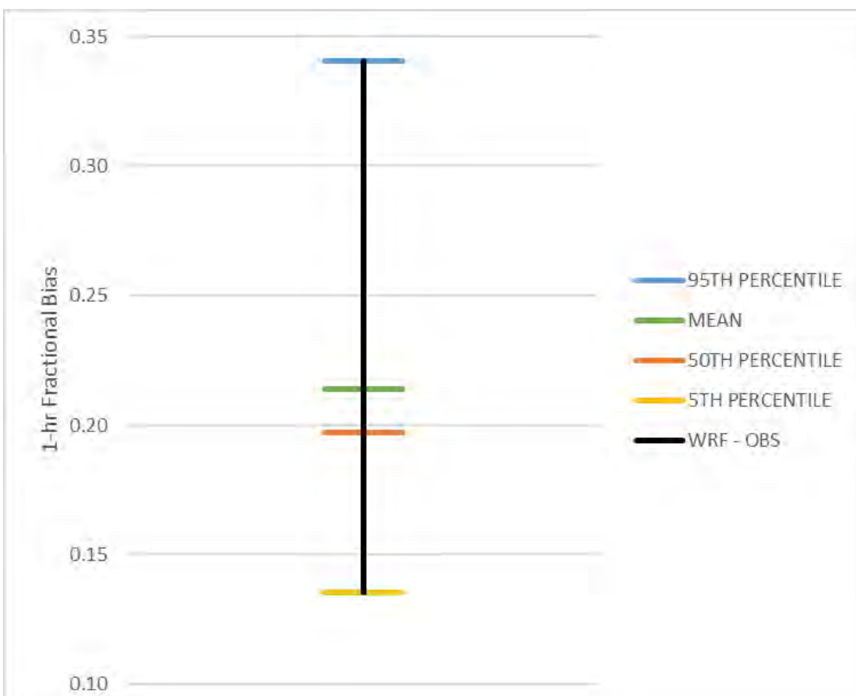


Figure A-15. Fractional Biases for Overwater 1-hour Average Concentrations

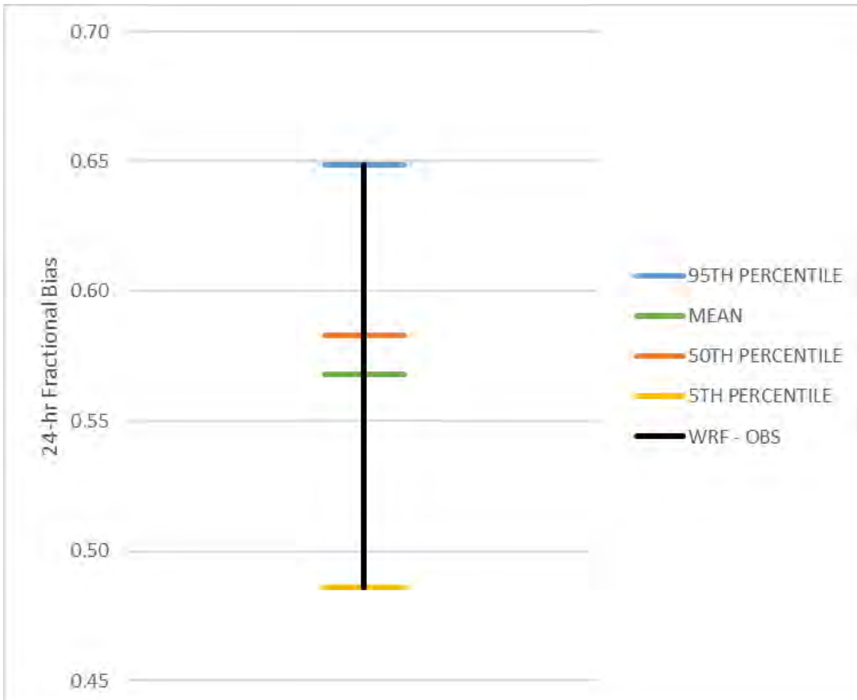


Figure A-16. Fractional Biases for Overwater 24-hour Average Concentrations

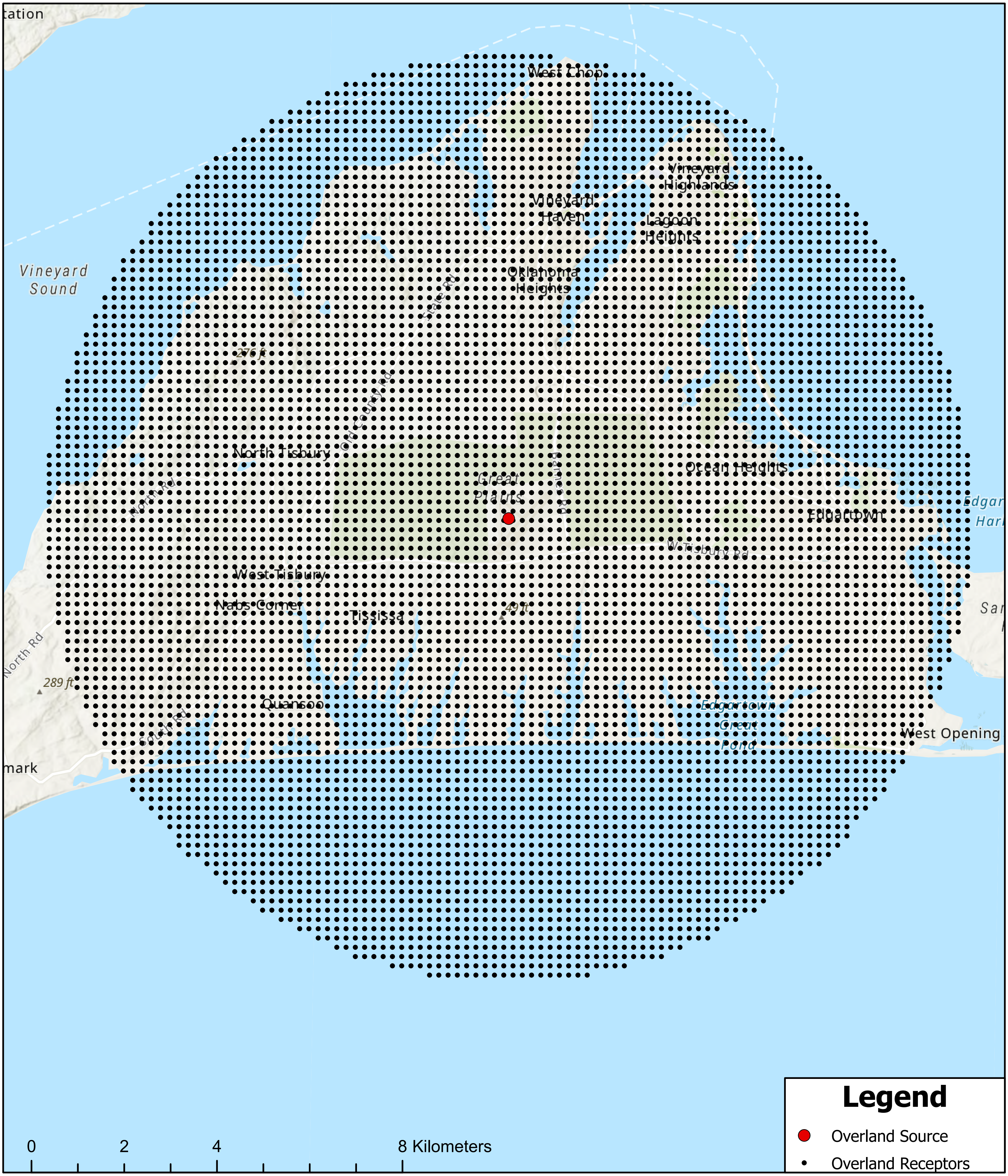


Figure A-17
Overland Source and Receptor Grid

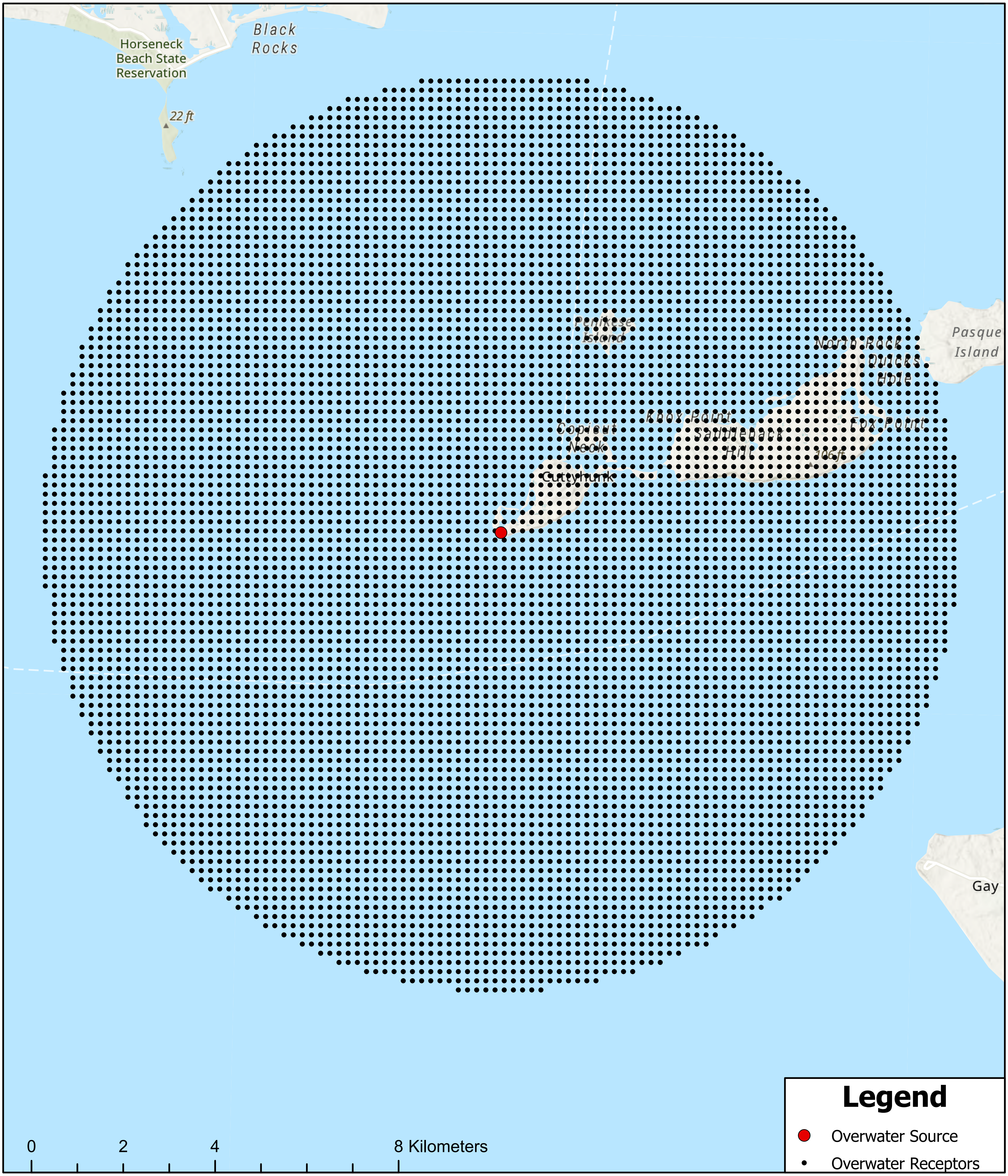


Figure A-18
Overwater Source and Receptors

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Appendix B

Model Source and Receptor Figures

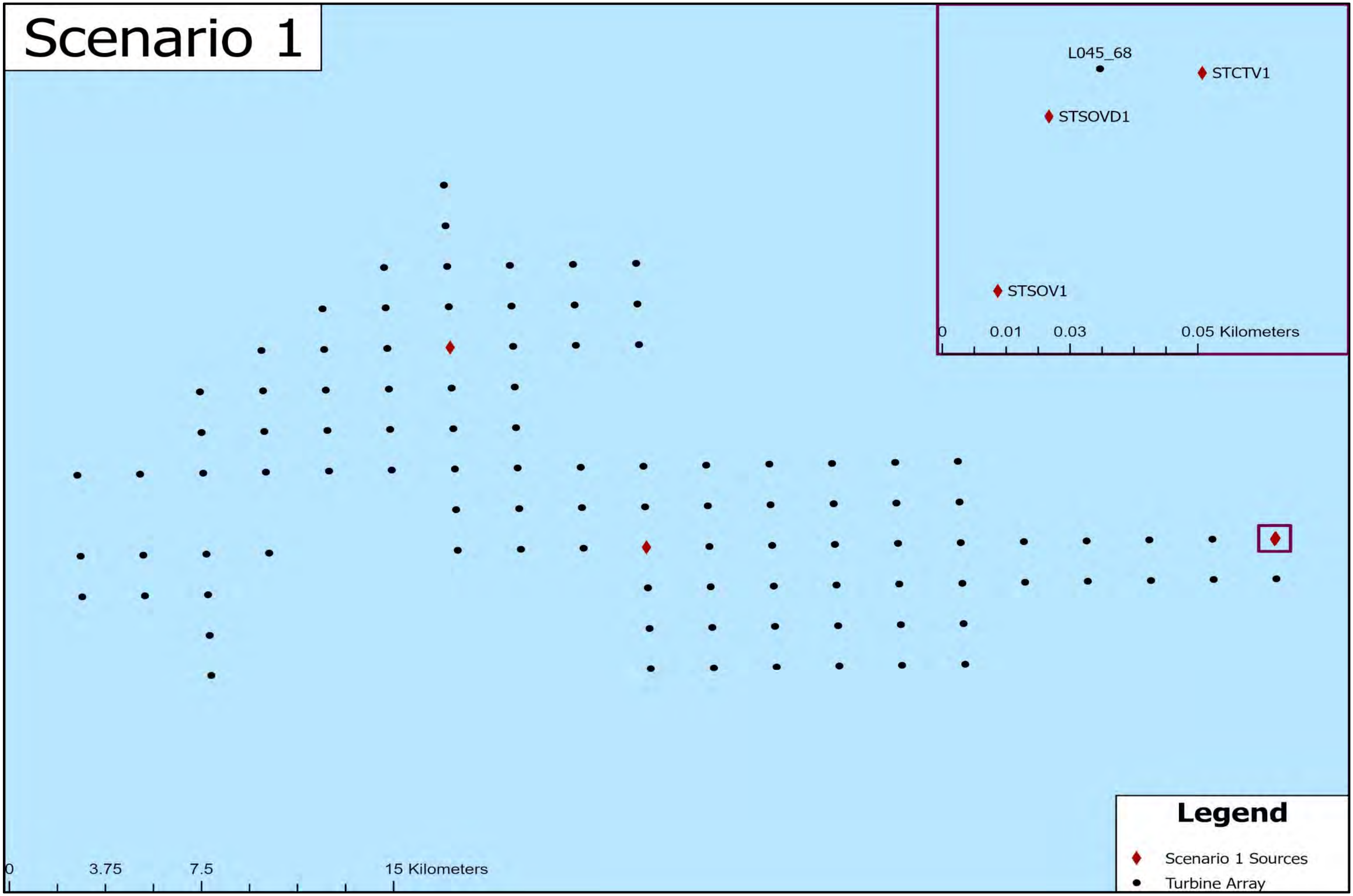

Figure B-1
Scenario 1
Revolution Wind O&M Model Sources

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Focused Knowledge. Real Solutions.

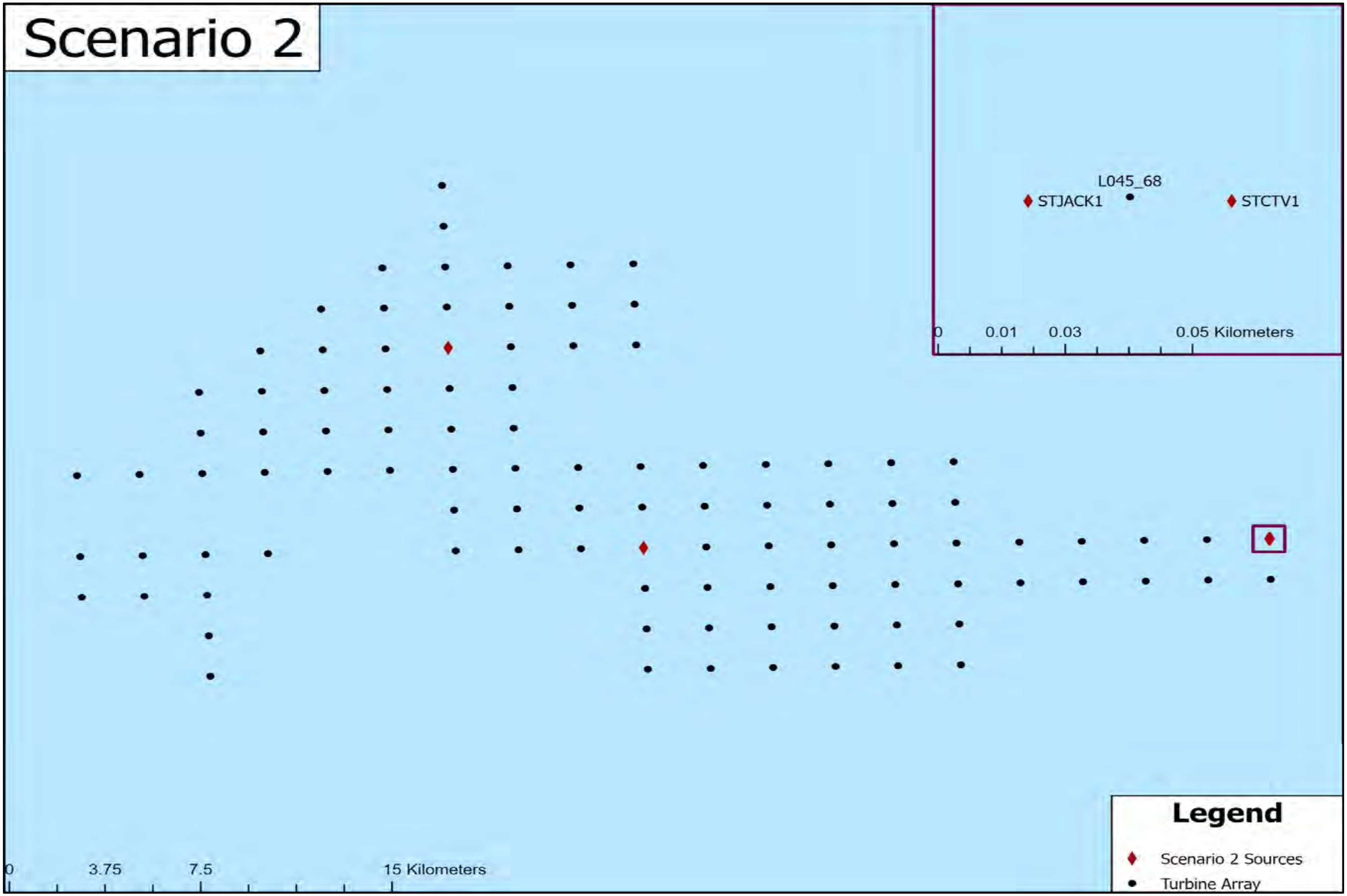

Figure B-2
Scenario 2
Revolution Wind O&M Model Sources

TECH environmental
Focused Knowledge. Real Solutions.

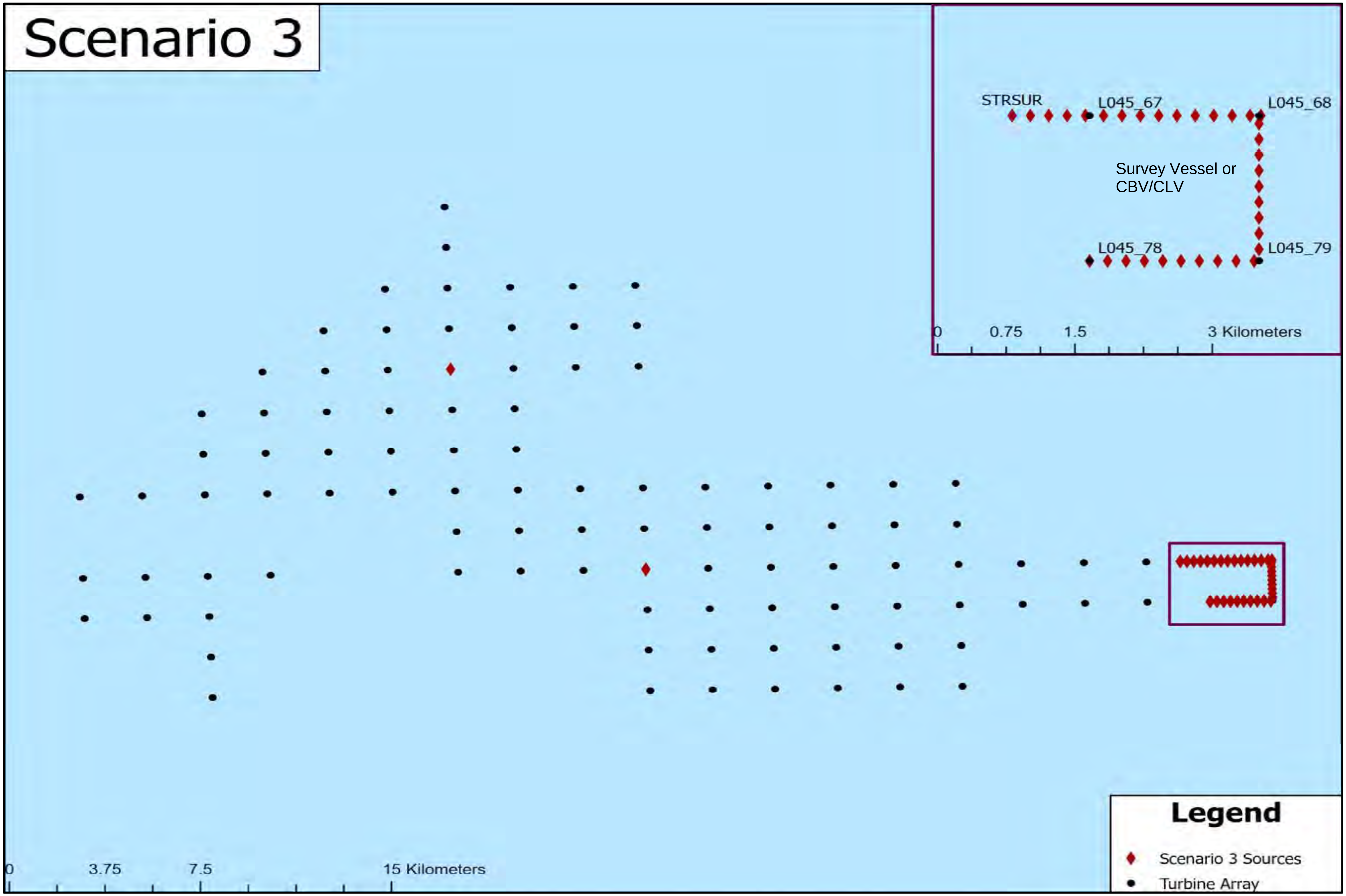

Figure B-3
Scenario 3 & 5
Revolution Wind O&M Model Sources

TECH environmental
Focused Knowledge. Real Solutions.

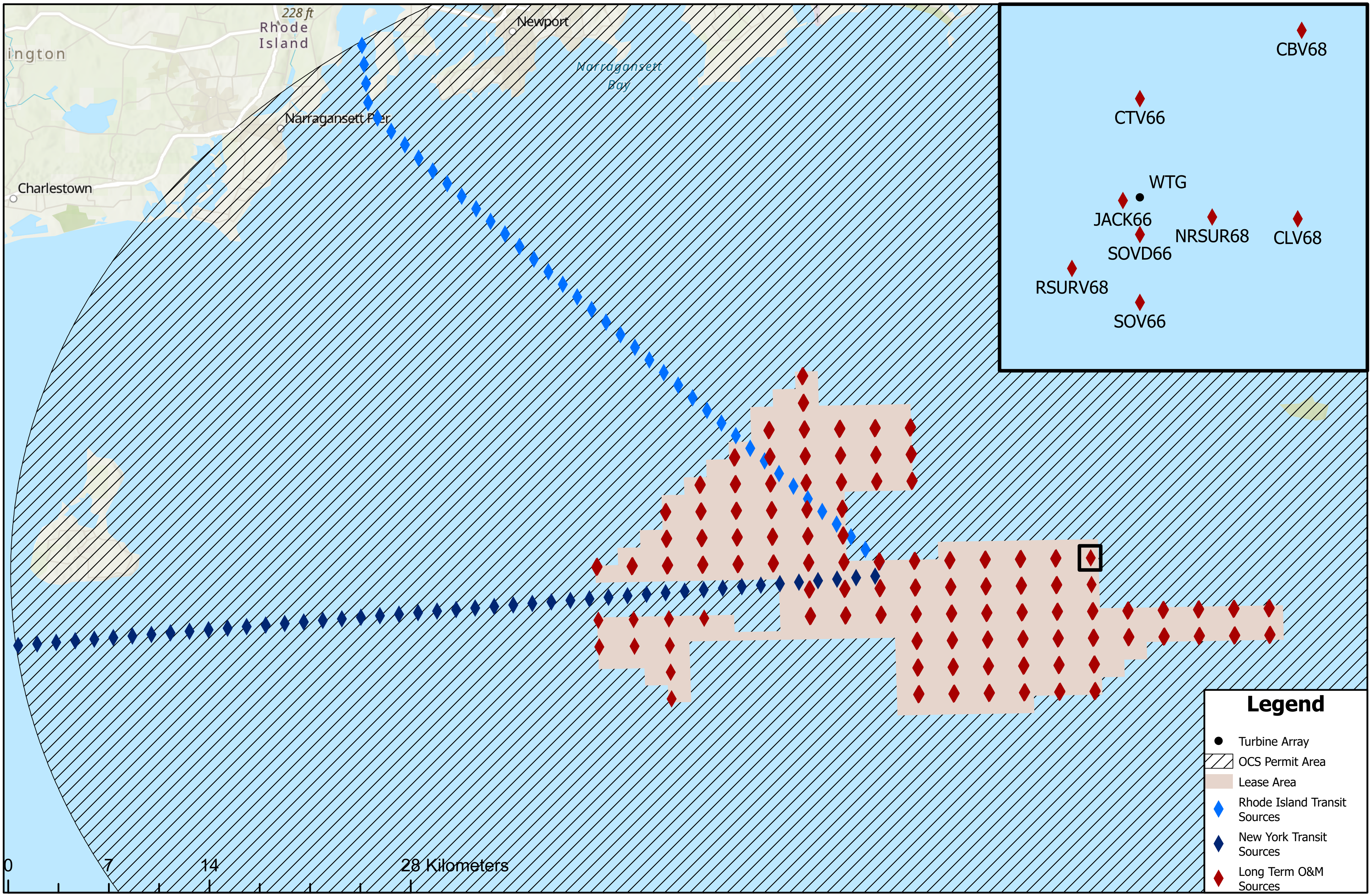

Figure B-4
Long Term
Revolution Wind O&M Model Sources

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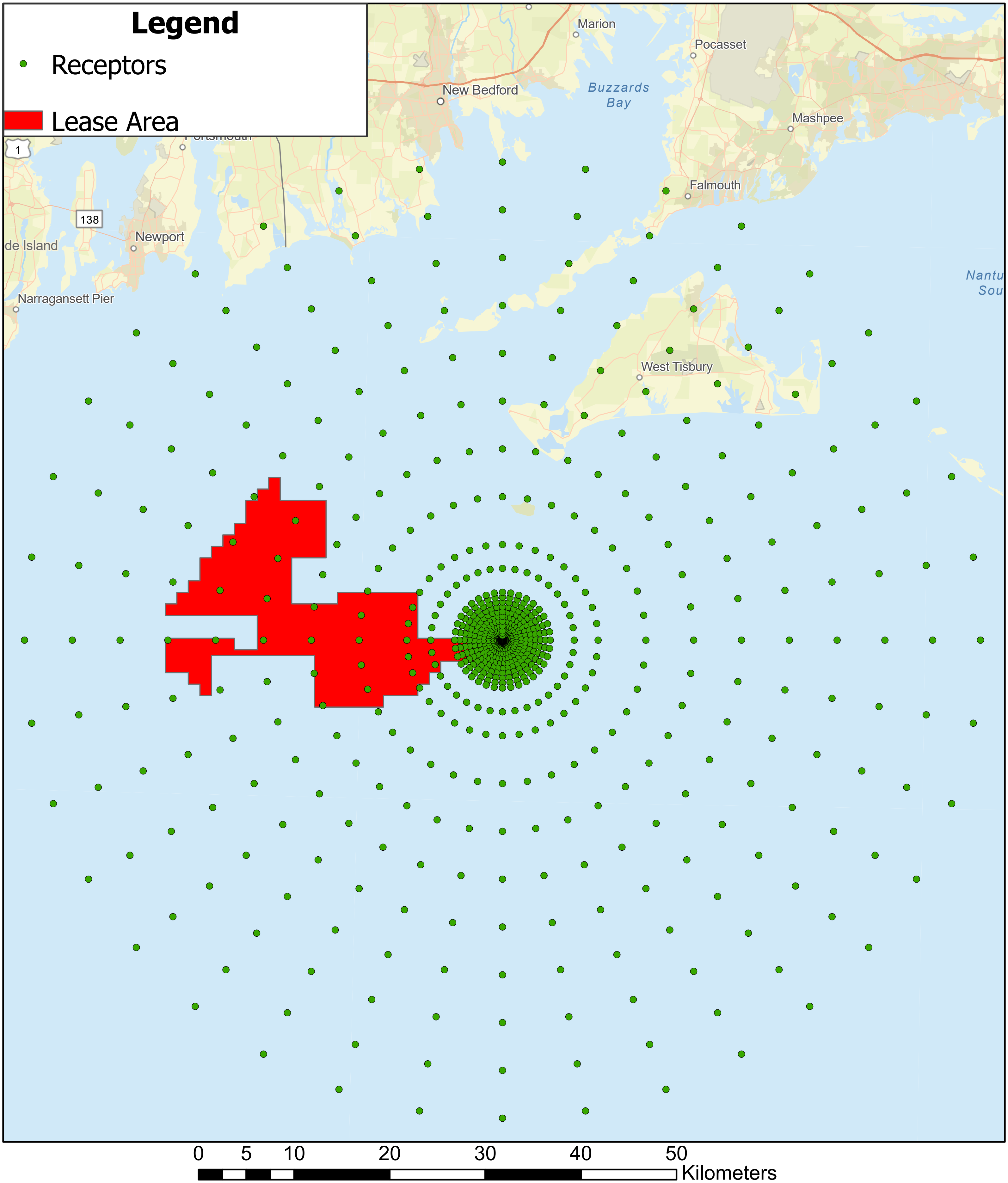

Figure B-5
O&M Short-term Receptor Locations
Revolution Wind

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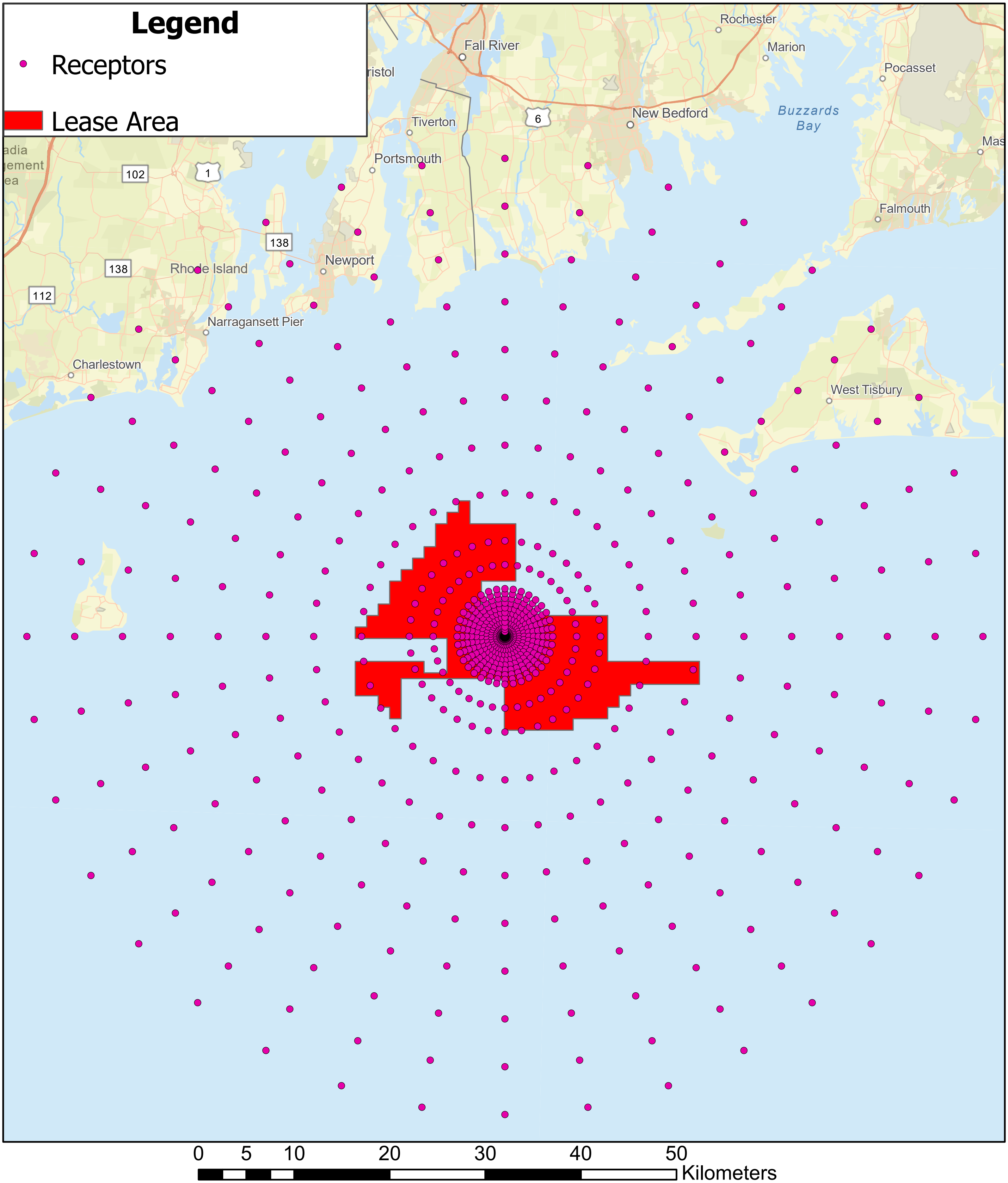

Figure B-6
O&M Long Term Receptor Locations
Revolution Wind

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Appendix C

EPA Protocol Comments and Revolution Wind Response to Comments

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 1
5 Post Office Square, Suite 100
Boston, MA 02109-3912

April 21, 2022

Mark Roll, Permitting Manager
NA Permitting
Ørsted
56, Exchange Terrace, Suite 300
Providence, Rhode Island 02903

Dear Mr. Roll:

Thank you for the opportunity to review the draft Air Quality Impact Modeling Protocol – Construction and O&M Emissions for the Revolution Wind Farm Project. We have reviewed the protocol and provided comments based on our review. Comments are included as an enclosure to this letter. Please respond to our comments and resubmit the protocol before submitting Revolution Wind Farm Project Outer Continental Shelf air permit application.

Again, thank you for the opportunity to review the protocol. If you have any questions, please contact Chris Howard at (404) 562-9036 or howard.chris@epa.gov.

Sincerely,

Patrick Bird, Manager
Air Permits, Toxics, and Indoor Programs Branch

Enclosure

Cc: Katherine Mears, Tech Environmental
Whitney Marsh, Ørsted

ENCLOSURE

US EPA Comments on PSD Modeling Protocols for Revolution Wind
April 21, 2022

CONSTRUCTION EMISSIONS MODELING PROTOCOL

Section 2.3.1 – PSD Class I Areas Impact Analysis, Section 4.1 - Class I Dispersion Modeling and Section 4.1.3 – Receptors

1. These sections indicate that if impacts predicted by the OCD model at a distance of 50 km from the source exceed the Class I PSD Increment SIL for NO_2, the modeling will look at impacts out to 75 km [40 nm]. We acknowledge that impacts predicted by the OCD model at a distance of 75 km from the source are likely conservative considering the distance to the nearest Class I area (252 km). Nevertheless, modeling receptors at a distance of 75 km from the source is inconsistent with subsection 4.2 of 40 CFR Part 51, Appendix W – The Guideline on Air Quality Models. If it is necessary to assess impacts beyond 50 km from the source, the approach described in subsection 4.2(c)(ii) of Appendix W may be used.

Section 3.1.1 – Revolution Wind Export Cable Installation OCS Source Applicability

2. This section makes the following statement: "*Per EPA's South Fork OCS Air Permit Fact Sheet, EPA no longer considers pull-ahead anchor cable laying vessels as meeting the definition of an OCS source (EPA, 2021a). Therefore, emissions from this vessel type are not included in the RWEC modeling, but have been included in the Project's PTE*." While EPA has found that the operating characteristics of a pull-ahead anchor cable laying vessel is not an OCS source, emissions associated with pull-ahead anchor cable laying vessels should be modeled in a similar manner to other vessels servicing or associated with and OCS source within 25 miles of the wind development area. We request you include in the modeling of construction impacts pull-ahead cable laying vessel emissions that occuring within 25 miles of the wind development area (WDA) once the first OCS source is present on WDA.

Section 3.1.2 Wind Turbine Generator Installation OCS Source Applicability

3. EPA seeks to maintain consistency with its precedent to date of considering all offshore substations and wind turbine generators associated with a particular project as part of a single OCS facility. For this reason, we request that emissions from vessels servicing or associated with the OCS facility, including emissions from vessels servicing or associated with the Wind Turbine Generators (WTGs) and occuring within 25 miles of the OCS facility, to be included in a modeling analysis across the entire wind development area for the construction, commissioning, and operations phases of the project.

4. This section states that in the unlikely scenario that there was not enough wind to charge the battery backup system ahead of the commissioning, temporary generators would be installed on the WTG for a few hours until the WTGs are connected to and are able to be powered by the grid. The protocol should clarify how the emissions from the temporary generators will be addressed in the

modeling. Alternatively, if these sources will not be included in the modeling, justification should be provided for not including them.

Section 4.1 Class I Dispersion Modeling

5. There is a probable typographical error in Table 4-2. The Class I SILs listed in Table 4-2 for annual NO_2 and 24-hour PM_{10} should be .1 and .3 $\mu g/m^3$, respectively.

Section 4.1.3 Receptors

6. This section states that the OCD modeling will be performed using a full 360-degree arc of receptors placed at 50 km from RWF. The receptors will be separated by 1 degree resulting in an effective receptor spacing of approximately 870m. Based on Figure B-1, the receptor grid will include some land areas in the northern portion of the modeling domain. Terrain elevations for some of the receptors located on land will be substantially greater than the tops of the shortest RWF stacks that will be modeled. Therefore, to ensure that these higher terrain areas are captured in the modeling, EPA recommends that additional receptors be placed in the higher terrain areas with elevations that exceed the equivalent height of the shortest stack being modeled.

Section 4.1.5 Model Scenarios

7. This section indicates that for 24-hour modeling, three unique scenarios are expected to occur. These scenarios will be modeled separately since they can be reasonably expected not to occur within the same 24-hour period. Based on our experience with other wind energy developers, it is our understanding that some of these activities would occur concurrently at different portions of the WDA. Please provide additional support or information to verify these scenarios are no expected to occur within the same 24-hour period.

Section 4.3.2 Transiting Vessels

8. This section states that transiting vessels will be modeled as 12 point sources stretching over the 25 nm (~40km) area from the lease area to the edge of the OCS Permit area. This equates to approximately one point source every 3.3km. While EPA appreciates the need to not overburden the model with point sources, we recommend that Tech Environmental consider simulating the transiting vessels with additional point sources, e.g., perhaps one point source very 1-2 km.

Section 4.4 NO_X to NO_2 Conversion

9. This section indicates that because the OCD model does not contain an algorithm to account for the formation of NO_2 from NO_X, the NO_2 results may be adjusted using the EPA-provided ARM2 post-processor spreadsheet. The final modeling report should clearly document how the ARM2 mechanism was accounted for in post-processing.

Section 4.5 Secondary Impacts

10. EPA is unable to duplicate the daily and annual NO_x impacts shown in **Table 4-8** based on annual NO_x emissions of 2,725 tpy. We request clarification on how these values were determined.

11. Using the search criterion described in the paragraph above **Table 4-9** (maximum precursor impacts at distances greater than or equal to 50km for hypothetical sources in the northeast climate zone), we are unable to confirm the following values in Table 4-9:

   - The CAMx impact for daily NO_x impacts (.127 µg/m^3 @ 500 tpy) listed in the Table. Using the Qlik application, we are showing a value of .414 µg/m^3 @ 3,000 tpy.
   - The CAMx impact for annual NO_x impacts (.0071 µg/m^3 @ 1,000 tpy) listed in the Table. Using the Qlik application, we are showing a value of .0119 µg/m^3 @ 3,000 tpy.
   - The CAMx emission rate for annual SO_2 (1000 tpy). Using the Qlik Application, we are showing 3,000 tpy corresponding to an annual CAMx impact of .031 µg/m^3; and
   - The computed project impacts using the CAMx impacts and emission rates in the table.

   We request clarification on how these values were determined.

12. EPA is unable to confirm the following values in Table 4-10:

   - The CAMx impact for daily NOx impacts (.0487 µg/m^3 @ 1,000 tpy). Using the Qlik application, we are showing a value of .0914 µg/m^3 @ 3000 tpy.
   - The CAMx impact for annual NOx impacts (.00155 µg/m^3 @ 1,000 tpy). Using the Qlik application, we are showing a value of .0024 µg/m^3 @ 3000 tpy; and
   - None of the computed project impacts with the exception of the computed project impact for Annual SO_2.

   We request clarification on how these values were determined.

13. The paragraph above Table 4-11 on page 22 of the modeling protocol states that EPA's MERPs guidance suggests using the maximum primary $PM_{2.5}$ impact at a distance greater than, or equal to, the distance the Project is from the nearest Class I area, 252 km [136 nm] away. The following is an excerpt from page 52 of Section 4.1.2 of EPA's April 2019 MERPs Guidance:

   "*Another option for this screening step would also involve selecting the highest modeled secondary $PM_{2.5}$ impact at or near the downwind distance of the Class I area relative to the project source but include an estimate of primary $PM_{2.5}$ impacts estimated with a chemical transport model (e.g., Lagrangian or photochemical model) <u>at or less than the downwind distance of the Class I area relative to the project source</u>*."

   Since the distance from the Project to the nearest Class I area is 252km, EPA recommends that a maximum distance of 200 km be used in the application of Table 4-2 of the MERPs Guidance.

O&M EMISSIONS MODELING PROTOCOL

<u>Section 2.3.3.2 – NAAQS Cumulative Impact Analysis</u>

14. This section presents four reasons supporting non-inclusion of any on-land sources in NAAQS cumulative modeling. EPA's concurrence with exclusion from cumulative modeling of the sources

located on Martha's Vineyard (Item 3) will, to a great extent, depend on the extent of the significant impact areas of the relevant pollutants for Revolution Wind, as well as the annual emissions of the sources proposed for exclusion.

15. This section also presents a case for not including South Fork Wind in a cumulative impact analysis for NAAQS modeling for Revolution Wind. After reviewing the relationship between Revolution Wind and South Fork Wind, EPA has preliminarily determined these two projects are the same stationary source for Clean Air Act permitting purposes.

    EPA regulations define "stationary source" as "any building, structure, facility, or installation which emits or may emit a regulated NSR pollutant."[1] Those regulations, in turn, define the term "building, structure, facility, or installation" to mean "all of the pollutant-emitting activities which [1] belong to the same industrial grouping, [2] are located on one or more contiguous or adjacent properties, and [3] are under the control of the same person (or persons under common control)," with "same industrial grouping" referring to the same Major Group, two-digit SIC code.[2] EPA commonly refers to this three-part analysis as a "source determination" analysis.

    The need for a cumulative impact analysis, within the context of EPA's Prevention of Significant Deterioration permitting program, may apply to the new Revolution Wind project. That is, if modeled impacts from Revolution Wind are above the SIL for any pollutant, a cumulative impact analysis that takes into account the pollutant emissions for South Fork Wind (and any nearby sources, if determined appropriate) would be required to be analyzed together, along with background concentrations. The protocol should be revised to account for the potential need for a cumulative impact analysis based on EPA's preliminary determination that the Revolution Wind and South Fork Wind projects are the same stationary source for Clean Air Act permitting purposes.

<u>Section 2.3.4.1 – PSD Increment Cumulative Analysis Approach</u>

16. This section presents a case for not including South Fork Wind in cumulative 24-hour PM10 and PM25 increment modeling for Revolution Wind. Like our comment regarding NAAQS modeling, a cumulative impact analysis may be required for increment if Revolution Wind models above the SIL for any pollutant. See comment #15 for more details on EPA's rationale for requiring this.

17. In this section, a case is presented for excluding South Fork Wind from any cumulative 24-hour PM_{10} and $PM_{2.5}$ increment modeling. Modeling performed by South Fork Wind in support of their permit indicated that 97% of the 24-hour $PM_{2.5}$ increment would be consumed. However, Tech Environmental argues that South Fork's modeling was overly conservative. Even though the modeling indicating near total consumption of the $PM_{2.5}$ increment is likely conservative, the modeling does at least indicate a potential issue with the 24-hour $PM_{2.5}$ increment in the area and this potential issue should be addressed. Since short term increments may only be exceeded once per year, and the 14 days of emissions associated with Scenario 2 could theoretically occur in one year, EPA recommends that South Fork be included in any cumulative $PM_{2.5}$ increment modeling for Revolution. In the unlikely event that compliance with the increment cannot be demonstrated when

[1] 40 CFR § 52.21(b)(5); 40 CFR § 51.165(a)(1)(i); 40 CFR § 51.166(b)(5); *see* 42 U.S.C. § 7602(z) (defining "stationary source" as "any source of an air pollutant" except those emissions resulting directly from certain mobile sources or engines).
[2] 40 CFR § 52.21(b)(6); 40 CFR § 51.165(a)(1)(ii); 40 CFR § 51.166(b)(6). A "source" should also comport with the "common sense notion of a plant," and avoid the aggregation of pollutant-emitting activities that would not fit within the ordinary meaning of "building, structure, facility or installation (45 FR at 52694)."

modeling South Fork conservatively, then we further recommend that South Fork be modeled in a more realistic (less conservative) manner. An additional alternative would be to demonstrate that the 24-hour PM_{10} and $PM_{2.5}$ significant impact areas for the two facilities do not overlap.

Section 2.4 Class II AQRV Assessments and Section 3.10 – Visibility

18. Section 2.4 indicates that based on preliminary emissions and distance to the nearest Class I location, it is not expected that impacts from the Project will have an adverse effect on visibility in the Class I area. Section 3.10 states that the results of the Q/D assessment will be summarized in the form "Request for Applicability of Class I Area Modeling Analysis" and provided to the U.S. Forest Service (USFS) for their determination on whether a Class I Air Quality Related Values (AQRV) analysis is needed. The USFS has requested an AQRV analysis for visibility impacts at Lye Brook from construction-related emissions.

Section 2.6 – Summary of Modeling Requirements

19. Table 2-9 of this section indicates that a Class I SIL analysis is not necessary for O&M emissions. Per Table 2-1, PSD is triggered for NO_x, PM_{10} and $PM_{2.5}$. Since Class I increments are established for these pollutants, a Class I SIL analysis is required.

Section 3.4.1 – Operations and Maintenance Activities

20. This section of the protocol states that there are four scenarios that are expected to occur during the O&M phase of the Project. These scenarios include:

    1) routine daily inspections and maintenance,
    2) nonroutine repairs of WTGs and OSSs,
    3) routine infrequent array cable and foundation surveys, and
    4) routine infrequent export cable surveys.

    The protocol states that the use of survey vessels for Scenarios 3 and 4, will occur along the cable routes and will not meet the definition of an OCS source. Therefore, only Scenarios 1 and 2 will be included in the modeling. While EPA has found that the operating characteristics of a pull-ahead anchor cable laying vessel is not an OCS source, vessel emissions associated with servicing or associated with an OCS source/facility and occuring within 25 miles of the wind development area should be considered direct emissions of the source. We request you include in the modeling of impacts scenario 3 and 4 vessel emissions that occuring within 25 miles of WDA once the first OCS source is present on WDA.

Section 3.4.2 – Non-routine Wind Turbine Generator Substation Repair Activities (Scenario 2) and
Section 3.4.3 – Daily Inspections and Maintenance Activities (Scenario 1)

21. An example calculation should be provided for one of the vessels or pieces of equipment shown in Tables 3-4 and 3-6. These example calculations should be provided for each pollutant and averaging period and identify the key assumptions used in the calculation. We recommend that this calculation be shown for the vessel or equipment with the largest emissions for each Scenario.

Section 3.4.4 – Transiting Vessels

22. This section states that transiting vessels will be modeled as 12 point sources stretching over the 25 nm (~40km) area from the lease area to the edge of the OCS Permit area. This equates to approximately one point source every 3.3km. While we appreciate the need to not overburden the model with point sources, we recommend that Tech Environmental consider simulating the transiting vessels with additional point sources, e.g., perhaps one point source very 1-2 km.

Section 3.5 - Nitrogen Oxide Conversion

23. Because the OCD model does not contain an algorithm to account for the formation of NO_2 from NO_X, the NO_2 results may be adjusted using ARM2 post-processing. The final modeling report should clearly document how the ARM2 mechanism was applied in post-processing.

Section 3.6 – Source Configuration of O&M Scenarios

24. Clarification is requested regarding the locations that will be used for the sources included in the long-term modeling.

Section 3.9 - Comparison to EPA Guidance

25. This section of the protocol presents justification for use of intermittent treatment of O&M activities for modeling 1-hour NO_2. Using this approach, for each WTG or OSS location, the O&M vessels will be modeled based on the number of hours per year they will be emitting at that location, divided by 8,760. On page 25 of Section 3.9, it is stated that for each WTG or OSS location, the O&M vessels were modeled based on the number of hours per year they would be emitting at that location, divided by 8,760. We would like confirmation that this annualization of emissions and associated modeled emission rates in Tables 3-4 and 3-6 were calculated in this manner.

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Boston, MA 02109-3912

April 26, 2022

Mark Roll, Permitting Manager
NA Permitting
Ørsted
56, Exchange Terrace, Suite 300
Providence, Rhode Island 02903

Dear Mr. Roll:

Thank you for the opportunity to review Appendix A to the Construction Modeling Protocol – Meteorological Data and Air Dispersion Modeling Comparisons for the Revolution Wind Farm Project. We have reviewed Appendix A and provide comments based on our review. Comments are included as an enclosure to this letter. Please respond to our comments and resubmit the comparison at your earliest convenience.

Again, thank you for the opportunity to review the comparison. If you have any questions, please contact Chris Howard at (404) 562-9036 or howard.chris@epa.gov.

Sincerely,

Patrick Bird, Manager
Air Permits, Toxics, and Indoor Programs Branch

Enclosure

Cc: Katherine Mears, Tech Environmental
Whitney Marsh, Ørsted

ENCLOSURE

US EPA Comments on Appendix A to the Revolution Wind Construction Modeling Protocol – Meteorological Data and Air Dispersion Modeling Comparisons for Revolution Wind

April 26, 2022

General Comment

1. The EPA requests that Appendix A be modified to define the mathematical formulas that are used to compute values of mean bias and fractional bias discussed in the Appendix. Mean and fractional bias are used in Appendix A to evaluate the performance of WRF/MMIF at predicting certain meteorological variables. These statistics are also used to compare air pollutant concentrations predicted by AERMOD using WRF/MMIF meteorological data to pollutant concentrations predicted by AERMOD using observed meteorological data. There are several instances in Section A.2.4 and in Section A.3 in which negative bias is described as under-prediction by WRF and positive bias is described as over-prediction by WRF. Confirmation is requested that the descriptions of over- or under-prediction by WRF are consistent with the formula used to compute fractional and mean bias.

Section A.2.4 – Comparison of Primary and Calculated Meteorological Parameters

2. The EPA recommends that the statistics comparing WRF data to observed data for KMVY, as shown in Tables A-2 through A-8, also be developed for the observed meteorological parameters for BUZM3. Based on the National Data Buoy Center website, the following meteorological parameters are collected at BUZM3: air temperature, atmospheric pressure, and wind speed.

3. In Tables A-6 through A-8, the values of R^2 are less than -1 for Heat Flux. EPA requests an explanation for these values.

4. In Tables A-2, A-3, A-4, A-6 and A-8, value of R^2 for the Monin-Obukhov Length are less than -1. EPA requests an explanation for these values.

5. Since water surface temperature is a required overwater input to the OCD model, EPA recommends that water temperature data from the Block Island buoy (buoy 44097) be compared to the water temperature in the extracted WRF data for the Revolution Wind centroid.

Section A.3 - Comparison of Dispersion Modeling Using Observed and Weather Research and Forecasting Meteorological Data

6. Even though several months of 2019 data were missing from the Buzzards Bay buoy, EPA recommends that available 2019 data be used in the comparative dispersion modeling analysis.

7. EPA recommends that a figure be included in Section A.3 to depict the locations of the single point sources modeled and the receptor grids used.

A.3.1 Overland Modeling Results

8. Explanation is requested regarding the statistical relationship between Figure A-7 and Figure A-9 and Figure A-8 and A-10.

A.3.2 Overwater Modeling Results

9. Figure A-13 depicts positive values of bias of the average greater than 2 for modeling for the 1-hour averaging period. Further discussion in the comparison of this issue is requested.

10. Explanation is requested regarding the statistical relationship between Figure A-13 and Figure A-15 and Figure A-14 and A-16.

Ørsted | EVERSOURCE

MEMORANDUM

To: Patrick Bird, Manager, EPA Region 1 – Air Permits, Toxics, and Indoor Programs Branch
From: Whitney Marsh, Ørsted
CC: Marc Wallace & Katherine Mears, Tech Environmental
Date: July 1, 2022
Subject: Revolution Wind OCS Air Permit Application- Construction and O&M Air Dispersion Modeling Protocol Response to Comments

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Tech Environmental, Inc. (Tech) is responding to EPA's comment letters, dated April 21 and April 26, 2022. In response to your comments, Tech has revised Revolution Wind's Air Quality Impact Modeling Protocol – Operations & Maintenance Emissions and Appendix A to the Air Quality Impact Modeling Protocol – Construction Emissions. Tech has provided responses below to address each of your received comments.

Construction Emissions Modeling Protocol

1. *Sections 2.3.1, 4.1 & 4.1.3. These sections indicate that if impacts predicted by the OCD model at a distance of 50 km from the source exceed the Class I PSD Increment SIL for NO2, the modeling will look at impacts out to 75 km [40 nm]. We acknowledge that impacts predicted by the OCD model at a distance of 75 km from the source are likely conservative considering the distance to the nearest Class I area (252 km). Nevertheless, modeling receptors at a distance of 75 km from the source is inconsistent with subsection 4.2 of 40 CFR Part 51, Appendix W – The Guideline on Air Quality Models. If it is necessary to assess impacts beyond 50 km from the source, the approach described in subsection 4.2(c)(ii) of Appendix W may be used.*

   Tech will perform the construction modeling via CALPUFF, rather than first modeling with OCD.

2. *Section 3.1.1. This section makes the following statement: "Per EPA's South Fork OCS Air Permit Fact Sheet, EPA no longer considers pull-ahead anchor cable laying vessels as meeting the definition of an OCS source (EPA, 2021a). Therefore, emissions from this vessel type are not included in the RWEC modeling, but have been included in the Project's PTE." While EPA has found that the operating characteristics of a pull-ahead anchor cable laying vessel is not an OCS source, emissions associated with pull-ahead anchor cable laying vessels should be modeled in a similar manner to other vessels servicing or associated with and OCS source within 25 miles of the wind development area. We request you include in the modeling of construction impacts pull-ahead cable laying vessel emissions that occurring within 25 miles of the wind development area (WDA) once the first OCS source is present on WDA.*

   Tech will include the cable-laying vessel emission within the construction modeling using CALPUFF.

3. <u>*Section 3.1.2.*</u> *EPA seeks to maintain consistency with its precedent to date of considering all offshore substations and wind turbine generators associated with a particular project as part of a single OCS facility. For this reason, we request that emissions from vessels servicing or associated with the OCS facility, including emissions from vessels servicing or associated with the Wind Turbine Generators (WTGs) and occurring within 25 miles of the OCS facility, to be included in a modeling analysis across the entire wind development area for the construction, commissioning, and operations phases of the project*

   The protocol includes emissions from vessels servicing or associated with the OCS facility, including emissions from vessels servicing or associated with the Wind Turbine Generators (WTGs) and occurring within 25 miles of the OCS facility, to be included in a modeling analysis across the entire wind development area for the construction, commissioning, and operations phases of the project. The protocol has been revised to make more evident.

4. <u>*Section 3.1.2.*</u> *This section states that in the unlikely scenario that there was not enough wind to charge the battery backup system ahead of the commissioning, temporary generators would be installed on the WTG for a few hours until the WTGs are connected to and are able to be powered by the grid. The protocol should clarify how the emissions from the temporary generators will be addressed in the modeling. Alternatively, if these sources will not be included in the modeling, justification should be provided for not including them*

   Most recent information from Revolution Wind is that if a WTG's battery backup system was not functioning during commissioning, a temporary generator would be installed on the WTG. Any such temporary generators would be 37 kW and would run for one hour per day every 3 days, for a total of 7 hours. Even if the battery backup systems were not functioning on all of the up to 100 WTGs, the total potential to emit for all of the temporary generators are de minimis. Using a 7.5 g/kW-hr emission factor, it was found that this exceedingly unlikely worst-case scenario would contribute only 0.21 tons of NO_X. Therefore, because the emissions of the exceedingly unlikely worst-case scenario results in de minimis emissions, that would be further hard to predict when they may occur, these emissions are being excluded from the modeling.

5. <u>*Section 4.1.*</u> *There is a probable typographical error in Table 4-2. The Class I SILs listed in Table 4-2 for annual NO2 and 24-hour PM10 should be .1 and .3 µg/m3, respectively.*

   The annual NO_2 SIL has been changed to 0.1 µg/m^3. EPA's April 27, 2018 memorandum, titled *Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program*, presents a 24-hour $PM_{2.5}$ Class I SIL of 0.27 µg/m^3. Is this value incorrect? If so, we will correct the value in Table 4-2 to 0.3 µg/m^3.

6. <u>*Section 4.1.3.*</u> *This section states that the OCD modeling will be performed using a full 360-degree arc of receptors placed at 50 km from RWF. The receptors will be separated by 1 degree resulting in an effective receptor spacing of approximately 870m. Based on Figure B-1, the receptor grid will include some land areas in the northern portion of the modeling domain. Terrain elevations for some of the receptors located on land will be substantially greater than the tops of the shortest RWF stacks*

that will be modeled. Therefore, to ensure that these higher terrain areas are captured in the modeling, EPA recommends that additional receptors be placed in the higher terrain areas with elevations that exceed the equivalent height of the shortest stack being modeled.

The construction modeling will instead use CALPUFF, which will have Class I receptors in Lye Brook Wilderness.

7. *Section 4.1.5. This section indicates that for 24-hour modeling, three unique scenarios are expected to occur. These scenarios will be modeled separately since they can be reasonably expected not to occur within the same 24-hour period. Based on our experience with other wind energy developers, it is our understanding that some of these activities would occur concurrently at different portions of the WDA. Please provide additional support or information to verify these scenarios are no expected to occur within the same 24-hour period.*

   The construction CALPUFF modeling will conservatively assume all of the emissions could occur concurrently.

8. *Section 4.3.2. This section states that transiting vessels will be modeled as 12-point sources stretching over the 25 nm (~40km) area from the lease area to the edge of the OCS Permit area. This equates to approximately one point source every 3.3km. While EPA appreciates the need to not overburden the model with point sources, we recommend that Tech Environmental consider simulating the transiting vessels with additional point sources, e.g., perhaps one point source very 1-2 km.*

   Tech will include transiting point sources every 1 km for O&M modeling using OCD, but construction modeling using CALPUFF will merge all of the emissions into a single source that will be conservatively located at the edge of the OCS Permit area nearest to Lye Brook Wilderness.

9. *Section 4.4. This section indicates that because the OCD model does not contain an algorithm to account for the formation of NO2 from NOX, the NO2 results may be adjusted using the EPA-provided ARM2 post- processor spreadsheet. The final modeling report should clearly document how the ARM2 mechanism was accounted for in post-processing.*

   The modeling report will detail how the ARM2 post-processing will be performed.

10. *Section 4.5. EPA is unable to duplicate the daily and annual NOx impacts shown in Table 4-8 based on annual NOx emissions of 2,725 tpy. We request clarification on how these values were determined.*

    The values presented in Table 4-8 will not be used for CALPUFF construction modeling. See response to Comment #12.

11. *Section 4.5. Using the search criterion described in the paragraph above Table 4-9 (maximum precursor impacts at distances greater than or equal to 50km for hypothetical sources in the northeast climate zone), we are unable to confirm the following values in Table 4-9:*

- *The CAMx impact for daily NOx impacts (.127 µg/m3 @ 500 tpy) listed in the Table. Using the Qlik application, we are showing a value of .414 µg/m3 @ 3,000 tpy.*
- *The CAMx impact for annual NOx impacts (.0071 µg/m3 @ 1,000 tpy) listed in the Table. Using the Qlik application, we are showing a value of .0119 µg/m3 @ 3,000 tpy.*
- *The CAMx emission rate for annual SO2 (1000 tpy). Using the Qlik Application, we are showing 3,000 tpy corresponding to an annual CAMx impact of .031 µg/m3; and*
- *The computed project impacts using the CAMx impacts and emission rates in the table.*

We request clarification on how these values were determined.

The values presented in Table 4-9 will not be used for CALPUFF construction modeling. See response to Comment #12.

12. *Section 4.5. EPA is unable to confirm the following values in Table 4-10:*
    - *The CAMx impact for daily NOx impacts (.0487 µg/m3 @ 1,000 tpy). Using the Qlik application, we are showing a value of .0914 µg/m3 @ 3000 tpy.*
    - *The CAMx impact for annual NOx impacts (.00155 µg/m3 @ 1,000 tpy). Using the Qlik application, we are showing a value of .0024 µg/m3 @ 3000 tpy; and*
    - *None of the computed project impacts with the exception of the computed project impact for Annual SO2.*

    We request clarification on how these values were determined.

    The NO_X values presented in Table 4-10 have been revised and represent the secondary emissions that will be used for the CALPUFF construction modeling. The below secondary impacts were estimated using 3,377 tpy of NO_X and 12.6 tpy of SO_2.

Table 4-10 Refined Second-Level Secondary $PM_{2.5}$ Impacts

Precursor	Daily $PM_{2.5}$				Annual $PM_{2.5}$			
	CAMx Impact (ug/m³)	CAMx Emission Rate (tpy)	Project Impact (ug/m³)	Total Impact (ug/m³)	CAMx Impact (ug/m³)	CAMx Emission Rate (tpy)	Project Impact (ug/m³)	Total Impact (ug/m³))
NO_X	0.0914	3,000	0.1029	0.1036	0.0024	3,000	0.002715	0.002739
SO_2	0.1738	3,000	0.0007		0.0057	3,000	0.000024	

13. *Section 4.5. The paragraph above Table 4-11 on page 22 of the modeling protocol states that EPA's MERPs guidance suggests using the maximum primary PM2.5 impact at a distance greater than, or equal to, the distance the Project is from the nearest Class I area, 252 km [136 nm] away. The following is an excerpt from page 52 of Section 4.1.2 of EPA's April 2019 MERPs Guidance:*

    "Another option for this screening step would also involve selecting the highest modeled secondary PM2.5 impact at or near the downwind distance of the Class I area relative to the project source but

include an estimate of primary PM2.5 impacts estimated with a chemical transport model (e.g., Lagrangian or photochemical model) at or less than the downwind distance of the Class I area relative to the project source."

Since the distance from the Project to the nearest Class I area is 252km, EPA recommends that a maximum distance of 200 km be used in the application of Table 4-2 of the MERPs Guidance.

If using CALPUFF for construction modeling, determining primary $PM_{2.5}$ impacts via MEPRs will be unnecessary.

O&M Emissions Modeling Protocol

14. Sections 2.3.3.2. *This section presents four reasons supporting non-inclusion of any on-land sources in NAAQS cumulative modeling. EPA's concurrence with exclusion from cumulative modeling of the sources located on Martha's Vineyard (Item 3) will, to a great extent, depend on the extent of the significant impact areas of the relevant pollutants for Revolution Wind, as well as the annual emissions of the sources proposed for exclusion.*

    Considering that EPA's memorandum "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard", cautions against applying nearby sources beyond 10 km, and the nearest reportable source is 18 km away, Tech took the approach that cumulative modeling of land-based sources would not be warranted. If one considers the extent of modeled impacts from other offshore wind projects, it can be reasonably expected that the extent of Revolution Wind impacts would not warrant modeling of land-based sources as has been the case for similar sized projects.

    The GenOn Power Canal LLC annual NO_X PTE is a little less than half of those expected from Revolution Wind's O&M phase. At 18 km away, it can be reasonably assumed that Revolution Wind's significant impact radius would have to extend out to at least 10 km to be reasonably considered as having the potential for cumulative impacts with GenOn Power Canal LLC.

15. Section 2.3.3.2. *This section also presents a case for not including South Fork Wind in a cumulative impact analysis for NAAQS modeling for Revolution Wind. After reviewing the relationship between Revolution Wind and South Fork Wind, EPA has preliminarily determined these two projects are the same stationary source for Clean Air Act permitting purposes.*

    EPA regulations define "stationary source" as "any building, structure, facility, or installation which emits or may emit a regulated NSR pollutant."[1] Those regulations, in turn, define the term "building, structure, facility, or installation" to mean "all of the pollutant-emitting activities which [1] belong to the same industrial grouping, [2] are located on one or more contiguous or adjacent properties, and [3] are under the control of the same person (or persons under common control)," with "same industrial grouping" referring to the same Major Group, two-digit SIC code.[2] EPA commonly refers to this three-part analysis as a "source determination" analysis.

The need for a cumulative impact analysis, within the context of EPA's Prevention of Significant Deterioration permitting program, may apply to the new Revolution Wind project. That is, if modeled impacts from Revolution Wind are above the SIL for any pollutant, a cumulative impact analysis that takes into account the pollutant emissions for South Fork Wind (and any nearby sources, if determined appropriate) would be required to be analyzed together, along with background concentrations. The protocol should be revised to account for the potential need for a cumulative impact analysis based on EPA's preliminary determination that the Revolution Wind and South Fork Wind projects are the same stationary source for Clean Air Act permitting purposes.

Tech proposes combining the SIL impacts presented in South Fork Wind's O&M Modeling Report with Revolution Wind's modeled SIL impacts and background concentrations and comparing those totals to the NAAQS. This method is conservative because it takes worst-case impacts for both projects and combines them without consideration for temporal or spatial alignment.

Pollutant	Averaging Period	NAAQS/ MAAQS	Selected Background Level	SFWF Impacts	Revolution Wind Cumulative Modeling Threshold
$PM_{2.5}$	24-hour	35	14.5	8.35	12.15
PM_{10}	24-hour	150	23.0	13.28	113.72

16. *<u>Section 2.3.4.1.</u> This section presents a case for not including South Fork Wind in cumulative 24-hour PM10 and PM25 increment modeling for Revolution Wind. Like our comment regarding NAAQS modeling, a cumulative impact analysis may be required for increment if Revolution Wind models above the SIL for any pollutant. See comment #15 for more details on EPA's rationale for requiring this.*

    As presented in the American Clean Power May 4, 2022 presentation, "Class II increments were intended to protect against prolonged exposure, which is not the case miles offshore". The only case of South Fork exceeding the SIL of a PSD Increment was for 24-hour $PM_{2.5}$ and PM_{10}, which was the result of modeling a repair activity that is only anticipated to occur for 14 days every two years. For a land-based facility, this type of activity likely would have never been modeled. If presented as a modification, the South Fork Wind Scenario 2 activity would have been well below the net emissions increase thresholds. A PSD Increment that is intended to protect against long-term exposure should not be applied to otherwise de minimis activity that occurs for 1.9% of any given year several kilometers from state waters and further be allowed to inaccurately consume 97% of an increment, as such a limited activity cannot reasonably be expected to cause a deterioration in air quality.

17. *<u>Section 2.3.4.1.</u> In this section, a case is presented for excluding South Fork Wind from any cumulative 24-hour PM10 and PM2.5 increment modeling. Modeling performed by South Fork Wind in support of their permit indicated that 97% of the 24-hour PM2.5 increment would be consumed. However, Tech Environmental argues that South Fork's modeling was overly conservative. Even though the modeling indicating near total consumption of the PM2.5 increment is likely conservative, the modeling does at least indicate a potential issue with the 24-hour PM2.5 increment in the area and*

this potential issue should be addressed. Since short term increments may only be exceeded once per year, and the 14 days of emissions associated with Scenario 2 could theoretically occur in one year, EPA recommends that South Fork be included in any cumulative PM2.5 increment modeling for Revolution. In the unlikely event that compliance with the increment cannot be demonstrated when modeling South Fork conservatively, then we further recommend that South Fork be modeled in a more realistic (less conservative) manner. An additional alternative would be to demonstrate that the 24-hour PM10 and PM2.5 significant impact areas for the two facilities do not overlap.

See Response to #16 above.

18. <u>Section 2.4.</u> *Section 2.4 indicates that based on preliminary emissions and distance to the nearest Class I location, it is not expected that impacts from the Project will have an adverse effect on visibility in the Class I area. Section 3.10 states that the results of the Q/D assessment will be summarized in the form "Request for Applicability of Class I Area Modeling Analysis" and provided to the U.S. Forest Service (USFS) for their determination on whether a Class I Air Quality Related Values (AQRV) analysis is needed. The USFS has requested an AQRV analysis for visibility impacts at Lye Brook from construction-related emissions.*

The Q/D assessment that was described in the O&M protocol was specific to O&M emissions. As detailed below, Tech disagrees that a Class I visibility assessment of Revolution Wind's construction phase emissions can be required, as 40 CFR 52.21(i) has explicit language that would exempt the project from such an analysis. Nevertheless, Revolution Wind has prepared a protocol for USFS to support their request despite not yet having the opportunity to demonstrate that the project is exempt.

Per 40 CFR 52.21(i),

> ***(3) The requirements of paragraphs (k), (m) and (o) of this section shall not apply to a major stationary source or major modification with respect to a particular pollutant, if the allowable emissions of that pollutant from the source, or the net emissions increase of that pollutant from the modification:***
> ***(i) Would impact no Class I area and no area where an applicable increment is known to be violated, and***
> ***(ii) Would be temporary.***

Because the project's construction phase is temporary and is not near any areas where an applicable increment is known to be violated, as EPA has previously found, the above exemption has always been on the table for Revolution Wind, as it has for previous offshore wind projects. If Revolution Wind demonstrates no impact to Class I areas during construction, then exemption from paragraph (o) applies, which would exempt the construction phase from performing a visibility analysis as explicitly stated in 40 CFR 52.21(o):

> ***(o) Additional impact analyses.***

(1) The owner or operator shall provide an analysis of the impairment to visibility, soils and vegetation that would occur as a result of the source or modification and general commercial, residential, industrial and other growth associated with the source or modification. The owner or operator need not provide an analysis of the impact on vegetation having no significant commercial or recreational value.
(2) The owner or operator shall provide an analysis or the air quality impact project for the area as a result of general commercial, residential, industrial and other growth associated with the source or modification.
(3) Visibility monitoring. The Administrator may require monitoring of visibility in any Federal class I area near the proposed new stationary source for major modification for such purposes and by such means as the Administrator deems necessary and appropriate.

At no point has any other project been required to demonstrate no visibility impacts at Class I areas to satisfy the criteria under 40 CFR 52.21(i)(3). In fact, when assessing whether previous projects have satisfied the criteria for the construction phase, EPA's Fact Sheets for Vineyard Wind and South Fork Wind make no mention of visibility impacts at Class I areas when making that determination.

19. *Section 2.6. Table 2-9 of this section indicates that a Class I SIL analysis is not necessary for O&M emissions. Per Table 2-1, PSD is triggered for NOx, PM10 and PM2.5. Since Class I increments are established for these pollutants, a Class I SIL analysis is required.*

    A 50 km ring of receptors with 1 degree spacing will be included in the O&M modeling to conservatively represent potential impacts at Class I areas. Furthermore, in response to EPA's comment #6, the 50 km receptor ring will include overland receptors every 100 km to ensure any complex terrain is captured.

20. *Section 3.4.1. This section of the protocol states that there are four scenarios that are expected to occur during the O&M phase of the Project. These scenarios include:*

    1) *routine daily inspections and maintenance,*
    2) *nonroutine repairs of WTGs and OSSs,*
    3) *routine infrequent array cable and foundation surveys and*
    4) *routine infrequent export cable surveys.*

    The protocol states that the use of survey vessels for Scenarios 3 and 4, will occur along the cable routes and will not meet the definition of an OCS source. Therefore, only Scenarios 1 and 2 will be included in the modeling. While EPA has found that the operating characteristics of a pull-ahead anchor cable laying vessel is not an OCS source, vessel emissions associated with servicing or associated with an OCS source/facility and occuring within 25 miles of the wind development area should be considered direct emissions of the source. We request you include in the modeling of impacts scenario 3 and 4 vessel emissions that occuring within 25 miles of WDA once the first OCS source is present on WDA.

The modeling will include Scenario 3. Scenario 4 is the same activity, located further from the OSS generators, so Scenario 3 has a higher potential for impacts and will be the Scenario modeled. The survey vessel is expected to survey 171 km of array cable within 26.7 days, equating to an average of 6.4 km per day. Therefore, the survey vessel emissions will be modeled as a point source located every 200 meters along the inter-array cables between the 5 WTGs nearest to shore, spanning 6,400 meters, for a total of 33 point sources.

21. <u>Section 3.4.2. & 3.4.3</u> *An example calculation should be provided for one of the vessels or pieces of equipment shown in Tables 3-4 and 3-6. These example calculations should be provided for each pollutant and averaging period and identify the key assumptions used in the calculation. We recommend that this calculation be shown for the vessel or equipment with the largest emissions for each Scenario.*

Example calculations will be included in the revised protocol. An example calculation for on-site (non-transit) short-term $PM_{2.5}$ emissions from the SOV auxiliary engine is below, which uses a Tier 4 emission factor, BOEM default engine ratings and a BOEM default load factor. This is the only O&M vessel emission calculation that uses a Tier 4 emission factor. The CTVs use an IMO Tier II emission factor for NO_X. All other O&M vessels use a BOEM default emission factor.

$$0.310\,\frac{g}{kWhr}\;x\;201\;kW\;x\;1.0\;x\;\frac{1\;hr}{3600\;s} = 0.0173\;g/s$$

For dynamic positioning vessels (all except CTVs, SOV daughter and jack-up), the main/propulsion engines are also calculated for on-site emissions and combined with the auxiliary engine emissions when determining on-site modeling emission rates. Below is an example of the short-term $PM_{2.5}$ emissions from the SOV main/propulsion engines, which uses a Tier 4 emission factor, vessel-specific engine ratings and a BOEM default load factor.

$$0.250\,\frac{g}{kWhr}\;x\;6920\;kW\;x\;0.2\;x\;\frac{1\;hr}{3600\;s} = 0.0961\;g/s$$

For 1-hour NO_X and long-term emissions calculations, the emission factors are also multiplied by the hours that each vessel is expected to be on-site and divided by 8,760 hours. Below are tables that provide the source of emission factors and engine ratings used in the emission calculations for each vessel.

Marine Vessel Main Engine Emission Factors (g/kW-hr)						
Vessel Type	**Applied to**	**CO**	**NOX**	**PM10**	**PM2.5**	**SO2**
Crew	SOV daughter	2.30	9.15	0.310	0.300	0.006
Jackup	Jack-up	2.30	10.03	0.308	0.298	0.013
Research/Survey	Survey	2.25	9.86	0.339	0.326	0.066
Crew / NOS Developer	CTVs	2.30	7.80	0.310	0.300	0.006
Crew / ECO Edison	SOV	2.30	1.80	0.250	0.250	0.006

Marine Vessel Auxiliary Engine Emission Factors (g/kW-hr)						
Vessel Type	**Applied to**	**CO**	**NOX**	**PM10**	**PM2.5**	**SO2**
Crew	SOV daughter	2.48	10.37	0.320	0.310	0.006
Jackup	Jack-up	2.48	11.55	0.320	0.310	0.006
Research/Survey	Survey	2.48	10.21	0.320	0.310	0.006
Crew / NOS Developer	CTVs	2.48	10.37	0.320	0.310	0.006
Crew / ECO Edison	SOV	2.48	1.80	0.250	0.250	0.006

Legend
IMO Tier II
EPA Tier 4
BOEM default

Marine Vessel Engine Defaults			
StandardType	**Applied to**	**Main kW**	**Aux kW**
Crew	SOV daughter	3013	201
Jackup	None	3215	895
Research/Survey	None	2997	1363
Crew / NOS Developer	CTVs	2204	201
Crew / ECO Edison	SOV	6920	201
Jackup / Pacific Orca	Jack-up	22400	895
Research/Survey / Helix Grand Canyon III	Survey	16637	1363

Legend
Vessel Specific - more than default
Vessel Specific - less than default
BOEM default

22. *<u>Section 3.4.4.</u> This section states that transiting vessels will be modeled as 12 point sources stretching over the 25 nm (~40km) area from the lease area to the edge of the OCS Permit area. This equates to approximately one point source every 3.3km. While we appreciate the need to not overburden the model with point sources, we recommend that Tech Environmental consider simulating the transiting vessels with additional point sources, e.g., perhaps one point source very 1-2 km.*

    The transit emissions modeling will be represented by point sources located every 1 km.

23. *<u>Section 3.5.</u> Because the OCD model does not contain an algorithm to account for the formation of NO2 from NOX, the NO2 results may be adjusted using ARM2 post-processing. The final modeling report should clearly document how the ARM2 mechanism was applied in post-processing.*

The modeling report will detail how the ARM2 post-processing will be performed.

24. *Section 3.6. Clarification is requested regarding the locations that will be used for the sources included in the long-term modeling.*

    Please see the attached figure depicting the source locations that are proposed for the long-term modeling.

25. *Section 3.9. This section of the protocol presents justification for use of intermittent treatment of O&M activities for modeling 1-hour NO2. Using this approach, for each WTG or OSS location, the O&M vessels will be modeled based on the number of hours per year they will be emitting at that location, divided by 8,760. On page 25 of Section 3.9, it is stated that for each WTG or OSS location, the O&M vessels were modeled based on the number of hours per year they would be emitting at that location, divided by 8,760. We would like confirmation that this annualization of emissions and associated modeled emission rates in Tables 3-4 and 3-6 were calculated in this manner.*

    There is a typo in the NO_X emission rate for the CTV that is presented in Table 3-4. The annualized NO_X emission rate for the Non-routine WTG and OSS Repair would be 0.014 grams per second instead of 0.2 grams per second. The NO_X emission rates presented in these tables are the total annualized emission rates from the source, rather than the emission rate that will be modeled at each location of activity.

Meteorological Data Evaluation

1. *The EPA requests that Appendix A be modified to define the mathematical formulas that are used to compute values of mean bias and fractional bias discussed in the Appendix. Mean and fractional bias are used in Appendix A to evaluate the performance of WRF/MMIF at predicting certain meteorological variables. These statistics are also used to compare air pollutant concentrations predicted by AERMOD using WRF/MMIF meteorological data to pollutant concentrations predicted by AERMOD using observed meteorological data. There are several instances in Section A.2.4 and in Section A.3 in which negative bias is described as under-prediction by WRF and positive bias is described as over-prediction by WRF. Confirmation is requested that the descriptions of over- or under-prediction by WRF are consistent with the formula used to compute fractional and mean bias.*

    A revised Appendix A is attached and includes defined mathematical formulas that are used to compute values of mean bias and fractional bias. These formulas are provided below. Some inconsistencies were identified in the calculations of Fractional Bias for the WRF/MMIF AERMOD modeling results and have been corrected. Throughout the evaluation, positive bias indicates overprediction by the WRF and negative bias indicates underprediction by the WRF. The meteorological data evaluation is being moved to the O&M protocol since the construction modeling will be using CALPUFF.

$$Mean\ Bias = \frac{1}{n}\sum_{1}^{n}(WRF - Observed)$$

$$Fractional\ Bias = \frac{2}{n}\sum_{i=1}^{n}\frac{(WRF_i - Observed_i)}{(WRF_i + Observed_i)}$$

2. *Section A.2.4. The EPA recommends that the statistics comparing WRF data to observed data for KMVY, as shown in Tables A-2 through A-8, also be developed for the observed meteorological parameters for BUZM3. Based on the National Data Buoy Center website, the following meteorological parameters are collected at BUZM3: air temperature, atmospheric pressure, and wind speed.*

   The revised Appendix A contains this information in Tables A-9 through A-15.

3. *Section A.2.4. In Tables A-6 through A-8, the values of R2 are less than -1 for Heat Flux. EPA requests an explanation for these values.*

   An error was identified, causing this issue, which has been corrected and the values are now within the expected range of 0 to 1.

4. *Section A.2.4. In Tables A-2, A-3, A-4, A-6 and A-8, value of R2 for the Monin-Obukhov Length are less than -1. EPA requests an explanation for these values.*

   See response to above Comment #3.

5. *Section A.2.4. Since water surface temperature is a required overwater input to the OCD model, EPA recommends that water temperature data from the Block Island buoy (buoy 44097) be compared to the water temperature in the extracted WRF data for the Revolution Wind centroid.*

   The revised Appendix A contains this information in Table A-16.

6. *Section A.3. Even though several months of 2019 data were missing from the Buzzards Bay buoy, EPA recommends that available 2019 data be used in the comparative dispersion modeling analysis.*

   The dispersion analysis was updated to include the 2019 Buzzards Bay buoy data that was available. Figures A-12 through A-16 now represent the comparative dispersion modeling using all available 2018 through 2020 data.

7. *Section A.3. EPA recommends that a figure be included in Section A.3 to depict the locations of the single point sources modeled and the receptor grids used.*

Figures A-17 and A-18 in revised Appendix A depict the source and receptor locations used for the overland and overwater meteorological comparison modeling.

8. <u>*Section A.3.1.*</u> *Explanation is requested regarding the statistical relationship between Figure A-7 and Figure A-9 and Figure A-8 and A-10.*

   Explanations of the relationships between the revised figures have been incorporated in the revised Appendix A.

9. <u>*Section A.3.2.*</u> *Figure A-13 depicts positive values of bias of the average greater than 2 for modeling for the 1-hour averaging period. Further discussion in the comparison of this issue is requested.*

   An error was identified causing the bias to appear larger than it is. The error has been corrected in Figure A-13.

10. <u>*Section A.3.2.*</u> *Explanation is requested regarding the statistical relationship between Figure A-13 and Figure A-15 and Figure A-14 and A-16.*

    Explanations of the relationships between the revised figures have been incorporated in the revised Appendix A.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
5 Post Office Square, Suite 100
Boston, MA 02109-3912

SENT VIA ELECTRONIC MAIL

July 20, 2022

Whitney Marsh, Environmental Manager
NA Permitting
Ørsted
56, Exchange Terrace, Suite 300
Providence, Rhode Island 02903
WHIMA@orsted.com

Re: EPA Review of July 1, 2022 Submittal for Revolution Wind, LLC

Dear Ms. Marsh:

On July 1, 2022, EPA received additional information from Revolution Wind, LLC (RW) responding to EPA's April 21 and 26, 2022 comments on the draft modeling protocol for the Revolution Wind offshore wind farm project. RW also provided the Revised Appendix A for Met Data Comparison and a revised offshore and coastal dispersion (OCD) meteorological data evaluation. EPA has reviewed the information submitted by RW and are providing comments based on our review. Comments are included as an enclosure to this letter.

Thank you for the opportunity to review the additional information. EPA looks forward to receiving a final modeling protocol for review for the Revolution Wind project. If you have any questions, please contact Chris Howard at (404) 562-9036 or howard.chris@epa.gov.

Sincerely,

Patrick Bird, Manager
Air Permits, Toxics, and Indoor Programs Branch

Enclosure

Cc: Katherine Mears, Tech Environmental
Marc Wallace, Tech Environmental

ENCLOSURE

EPA Review of July 1, 2022, Revolution Wind (RW) Response to Comments on Modeling Protocol, Revised Appendix A to the RW Construction Modeling Protocol – Meteorological Data and Revised Offshore and Coastal Dispersion (OCD) Meteorological Data Evaluation.

RW Response to Comment #4 Re: Section 3.1.2

1. RW provided information to support the exclusion of temporary generators on the wind turbine generators (WTGs) from the modeling. EPA agrees with RW's assessment that the emissions from the temporary generators would be de minimus and may be excluded from modeling. EPA recommends that the construction emissions modeling protocol be revised to include this information in Section 3.1.2. Alternatively, rather than excluding these sources from the modeling, RW may consider including emissions from the temporary generators in the modeling using an average hourly emission rate, rather than the maximum hourly emission rate. For example, RW may multiply the maximum hourly emission rate for the generators by the ratio of the permitted yearly hours of operation to 8,760 hours. This approach for modeling intermittent sources is discussed in the first full paragraph on page 11 of the EPA's March 1, 2011, memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour $N0_2$, National Ambient Air Quality Standard".

RW Response to Comment #5 Re: Section 4.1

2. The recommended Class I SIL for 24-hour $PM_{2.5}$ is .27 $\mu g/m^3$.

RW Response to Comment #14 Re: Section 2.3.3.2

3. EPA agrees with RW's analysis for excluding GenOn Power from the cumulative National Ambient Air Quality Standard (NAAQS) modeling. EPA recommends that RW revise the O&M emissions modeling protocol to include this information in Section 2.3.3.2. EPA also requests that the annual NOx PTE for GenOn Power be quantified.

RW Response to Comment #15 Re: Section 2.3.3.2

4. Although RW's response addresses cumulative 24-hour PM_{10} and $PM_{2.5}$ NAAQS analyses, it does not appear to address a 1-hour NO_2 cumulative NAAQS analysis. EPA recommends RW clarify in the protocol if the approach proposed for addressing 24-hour PM_{10} and $PM_{2.5}$ is also being proposed for the 1-hour NO_2 NAAQS. RW's proposed approach, which combines modeled significant impact level (SIL) impacts from RW with modeled SIL impacts from South Fork Wind, without consideration of temporal or spatial alignment, is conservative and would be acceptable for assessing cumulative NAAQS impacts from the two projects for the 24-hour PM_{10} and $PM_{2.5}$ NAAQS, as well as the 1-hour NO_2 NAAQS. If RW is not proposing to use the same approach for the cumulative 1-hour NO_2 NAAQS analysis, please see the next comment.

5. The RW O&M Modeling Protocol, dated February 17, 2022, presents information to support exclusion of South Fork Wind (SFW) sources from cumulative modeling for the 1-hour NO_2 NAAQS. The basis for exclusion of SFW sources from cumulative modeling for the 1-hour NO_2 NAAQS is that the operational scenario (Scenario 2) for SFW that results in the greatest 1-hour NO_2

impact is intermittent in nature based on EPA's March 1, 2011, memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour $N0_2$, National Ambient Air Quality Standard". EPA recommends that the discussion at the top of page 13 in Section 2.3.3.2 of the O&M modeling protocol be revised to confirm that Scenario 2 represents non-routine maintenance and repair and that these operations do not occur on a scheduled basis.

Alternatively, rather than excluding the SFW Scenario 2 sources from the modeling, another approach that may be considered in this case would be to include SFW Scenario 2 emissions in cumulative modeling for the 1-hour NO_2 NAAQS by using an average hourly NO_x emissions rate, rather than the maximum hourly emission rate. For example, multiply the maximum hourly NO_x emission rate for the Scenario 2 sources by the ratio of permitted yearly hours of operation to 8,760 hours. This approach for modeling intermittent sources is discussed in the first full paragraph on page 11 of the EPA's March 1, 2011, memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour $N0_2$, National Ambient Air Quality Standard".

<u>RW Response to Comment #16 and 17 Re: Section 2.3.4.1</u>

6. The EPA has reviewed RW's proposed rationale for exclusion of SFW Scenario 2 emissions from a cumulative 24-hour $PM_{2.5}$ and PM_{10} PSD increment analysis. While the rationale provided by RW has merit, EPA's preference is to not rely on this rationale as the sole basis for exclusion of the SFW Scenario 2 sources from the cumulative increment modeling. Therefore, in addition to the information presented in Section 2.3.4.1 of the O&M modeling protocol, the EPA continues to recommend the alternative approach provided in our July 1, 2022, comment letter, which is to demonstrate that the 24-hour PM_{10} and $PM_{2.5}$ significant impact areas for SFW and Revolution Wind are several km apart and do not overlap.

<u>RW Response to Comment #19 Re: Section 2.6</u>

7. EPA agrees with RW's response and recommends that this approach be described in the O&M modeling protocol.

<u>RW Response to Comment #20 Re: Section 3.4.1</u>

8. The EPA agrees with RW's response and recommends that the information provided in this response be included in Section 3.4.1 of the O&M modeling protocol.

<u>RW Response to Comment #24 Re: Section 3.6</u>

9. In response to comment #24, RW referenced an attached figure depicting the source locations that are proposed for the long-term modeling. However, the referenced figure was not provided as an attachment for EPA review. Please provide the figure for EPA review.

<u>General Comment on Revolution Wind Meteorological Data Evaluation</u>

10. EPA recommends that either Section 3.3 of the O&M Modeling Protocol or Appendix A be revised to include a short summary of the processing steps taken to develop the overland and overwater meteorological input files required for the OCD regulatory modeling.

RW Response to Comment #7 Re: Meteorological Data Evaluation

11. In response to comment #7 regarding the meteorological data evaluation, RW referenced Figures A-17 and A-18 in the revised Appendix A. However, the referenced figures were not included in the revised Appendix A. Please provided the referenced figures for EPA review.

Ørsted | EVERSOURCE

MEMORANDUM

To: Patrick Bird, Manager, EPA Region 1 – Air Permits, Toxics, and Indoor Programs Branch
From: Whitney Marsh, Ørsted
CC: Marc Wallace & Katherine Mears, Tech Environmental
Date: August 12, 2022
Subject: Revolution Wind OCS Air Permit Application - O&M Air Dispersion Modeling Protocol Response to Comments

---

On July 1, 2022, Tech Environmental, Inc. (Tech) provided a response to EPA's comments received on April 21 and 26, 2022, regarding the Construction and O&M Air Dispersion Modeling Protocols. Tech's July 1, 2022 responses to these comments included a revised Offshore and Coastal Dispersion model (OCD) Meteorological Data Evaluation. Since submitting these materials, Tech has provided EPA with a separate protocol for performing the construction Class I SILs and Visibility modeling using CALPUFF. This new protocol was provided to EPA on July 8, 2022, and EPA has since provided comments which have been incorporated into a revised CALPUFF protocol.

In response to the materials submitted on July 1, 2022, EPA provided additional comments on July 20, 2022. This memorandum has been prepared in response to those additional comments. However, in some cases, EPA's comments pertain to the old construction protocol that originally proposed use of the OCD model. Since the construction modeling will no longer be using the OCD model and Revolution Wind has responded to separate comments on the new CALPUFF Construction Class I SILs and Visibility Protocol, this response to EPA's July 20, 2022 comments will not address comments on the construction modeling. Tech has provided responses below to address each of your received O&M protocol comments.

3. *<u>RW Response to Comment #14 Re: Section 2.3.3.2.</u> EPA agrees with RW's analysis for excluding GenOn Power from the cumulative National Ambient Air Quality Standard (NAAQS) modeling. EPA recommends that RW revise the O&M emissions modeling protocol to include this information in Section 2.3.3.2. EPA also requests that the annual NOx PTE for GenOn Power be quanitified.*

   Tech has revised the O&M protocol to include our reasoning for excluding GenOn Power from the cumulative modeling.

   Martha's Vineyard's primary energy source is provided to the island via four 23.2-kilovolt underwater cables. The GenOn power plants supplement this power supply during peak demand. According to the Facilities' Massachusetts Operating Permits, in a typical year the units operate fewer than 1,000 hours each, and some units operate fewer than 100 hours. The two GenOn power plants have a total of five 2.5 MW generators, each with a brake horsepower of 3,600 bhp. According to their permits, the NOX emission limit when operating for less than 1,000 hours per year is 9.0 g/bhp-hr, and the NOX emission limit when operating for more than 1,000 hours per year is 2.3 g/bhp-hr.

A 2021 article published in the Vineyard Gazette included fuel consumption estimates needed to keep up with electricity demand on the island for the following five years. The estimate by Rob Hannemann, engineer and former Tufts professor who lives in Chilmark and has been a leader on the climate action committee, was between 300,000 and 500,000 gallons per year. Each of the generators have a fuel consumption rate of 209 gallons per hour; therefore, the total required usage to meet this demand for all five generators is a combined 2,392 hours, or 478 hours each when divided evenly over the five generators.

Therefore, the emissions from these two facilities have been conservatively calculated assuming that each of the five units will operate for 1,000 hours (a combined 5,000 hours) with a NOX emission factor of 9.0 g/bhp-hr. Under this conservative scenario, the total emissions from the five 3,600 bhp generators would be equal to 179 tons per year, or 86% of Revolution Wind's estimated O&M emissions. Based on this relationship, it is estimated that Revolution Wind's NOx significant impact radius would need to extend out to at least 10 km to overlap with that of GenOn Canal's.

4. *<u>RW Response to Comment #15 Re: Section 2.3.3.2.</u> Although RW's response addresses cumulative 24-hour PM10 and PM2.5 NAAQS analyses, it does not appear to address a 1-hour NO2 cumulative NAAQS analysis. EPA recommends RW clarify in the protocol if the approach proposed for addressing 24-hour PM10 and PM2.5 is also being proposed for the 1-hour NO2 NAAQS. RW's proposed approach, which combines modeled significant impact level (SIL) impacts from RW with modeled SIL impacts from South Fork Wind, without consideration of temporal or spatial alignment, is conservative and would be acceptable for assessing cumulative NAAQS impacts from the two projects for the 24-hour PM10 and PM2.5 NAAQS, as well as the 1-hour NO2 NAAQS. If RW is not proposing to use the same approach for the cumulative 1-hour NO2 NAAQS analysis, please see the next comment.*

5. *The RW O&M Modeling Protocol, dated February 17, 2022, presents information to support exclusion of South Fork Wind (SFW) sources from cumulative modeling for the 1-hour NO2 NAAQS. The basis for exclusion of SFW sources from cumulative modeling for the 1-hour NO2 NAAQS is that the operational scenario (Scenario 2) for SFW that results in the greatest 1-hour NO2 impact is intermittent in nature based on EPA's March 1, 2011, memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour N02, National Ambient Air Quality Standard". EPA recommends that the discussion at the top of page 13 in Section 2.3.3.2 of the O&M modeling protocol be revised to confirm that Scenario 2 represents non-routine maintenance and repair and that these operations do not occur on a scheduled basis.*

   Alternatively, rather than excluding the SFW Scenario 2 sources from the modeling, another approach that may be considered in this case would be to include SFW Scenario 2 emissions in cumulative modeling for the 1-hour NO2 NAAQS by using an average hourly NOx emissions rate, rather than the maximum hourly emission rate. For example, multiply the maximum hourly NOx emission rate for the Scenario 2 sources by the ratio of permitted yearly hours of operation to 8,760 hours. This approach for modeling intermittent sources is discussed in the first full paragraph on page 11 of the EPA's

March 1, 2011, memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-Hour N02, National Ambient Air Quality Standard".

For 1-hour NO_X, Tech plans to use the conservative approach in EPA's Comment #4 of combining the modeled SIL impacts from Revolution Wind and SFW to demonstrate compliance with the 1-hour NAAQS without taking into consideration spatial or temporal alignment. That said, Tech will not know whether this approach will be too conservative until after the modeling is performed; therefore, Tech may need to revisit the other options discussed in EPA's Comment #5 if needed.

6. *<u>RW Response to Comment #16 and 17 Re: Section 2.3.4.1.</u> The EPA has reviewed RW's proposed rationale for exclusion of SFW Scenario 2 emissions from a cumulative 24-hour PM2.5 and PM10 PSD increment analysis. While the rationale provided by RW has merit, EPA's preference is to not rely on this rationale as the sole basis for exclusion of the SFW Scenario 2 sources from the cumulative increment modeling. Therefore, in addition to the information presented in Section 2.3.4.1 of the O&M modeling protocol, the EPA continues to recommend the alternative approach provided in our July 1, 2022, comment letter, which is to demonstrate that the 24-hour PM10 and PM2.5 significant impact areas for SFW and Revolution Wind are several km apart and do not overlap.*

   EPA and Revolution Wind have engaged in many discussions on the topic of evaluating $PM_{2.5}$ and PM_{10} PSD Increments. Most recently, Tech provided a proposed approach via email on July 27, 2022. The email proposed three approaches:

   1. **A significant impact radius comparison of $PM_{2.5}$ and PM_{10} to determine if the two projects significant impact areas overlap.**
   2. **A concentration gradient comparison of $PM_{2.5}$ and PM_{10} to determine if the overlapping portions of the significant impact radiuses have any mathematical possibility of exceeding the PSD Increment.**
   3. **Performing cumulative modeling of SFW's Scenario 2 emissions but annualizing the emission rates to account for the very infrequent operations.**

   After discussing with OAQPS, Pat Bird responded to this email on August 9, 2022, and approved the first two approaches described above. The third approach was not approved. In place of this approach, EPA recommended performing cumulative modeling of SFW's more typical operational scenario (i.e., Scenario 1). In response to this exchange with EPA, Revolution Wind agrees to performing this three-step approach with the third step including cumulative modeling of SFW's Scenario 1 emissions.

7. *<u>RW Response to Comment #19 Re: Section 2.6.</u> EPA agrees with RW's response and recommends that this approach be described in the O&M modeling protocol.*

   The O&M Modeling Protocol has been revised to include this approach.

8. *RW Response to Comment #20 Re: Section 3.4.1. The EPA agrees with RW's response and recommends that the information provided in this response be included in Section 3.4.1 of the O&M modeling protocol.*

   The O&M Modeling Protocol has been revised to include this information.

9. *RW Response to Comment #24 Re: Section 3.6. In response to comment #24, RW referenced an attached figure depicting the source locations that are proposed for the long-term modeling. However, the referenced figure was not provided as an attachment for EPA review. Please provide the figure for EPA review.*

   The figure is included in the revised O&M Modeling protocol.

10. *General Comment on Revolution Wind Meteorological Data Evaluation. EPA recommends that either Section 3.3 of the O&M Modeling Protocol or Appendix A be revised to include a short summary of the processing steps taken to develop the overland and overwater meteorological input files required for the OCD regulatory modeling.*

    Section 3.3 of the O&M Modeling Protocol has been revised to elaborate on the processing of the overland and overwater meteorological input files for the OCD modeling.

11. *RW Response to Comment #7 Re: Meteorological Data Evaluation. In response to comment #7 regarding the meteorological data evaluation, RW referenced Figures A-17 and A-18 in the revised Appendix A. However, the referenced figures were not included in the revised Appendix A. Please provide the referenced figures for EPA review.*

    The figures are provided in the revised Appendix A of the O&M Modeling Protocol.